PI: **Munson, Benjamin R**	Title: Race, Ethnicity, and Speech Intelligibility in Normal Hearing and Hearing Impairment	
Received: 10/15/2018	Opportunity: PA-18-489 Clinical Trial:Not Allowed	Council: 05/2019
Competition ID: FORMS-E	FOA Title: NIH Exploratory/Developmental Research Grant Program (Parent R21 Clinical Trial Not Allowed)	
1R21DC018070-01	Dual: MD	Accession Number: 4227645
IPF: 1450402	Organization: [redacted]	
Former Number:	Department: Speech-Language-Hearing Sci.	
IRG/SRG: LCOM	AIDS: N	Expedited: N
Subtotal Direct Costs (excludes consortium F&A) Year 1: [redacted] [redacted] [redacted]	Animals: N Humans: Y Clinical Trial: N Current HS Code: 30 HESC: N	New Investigator: Early Stage Investigator:
Senior/Key Personnel:	*Organization:*	*Role Category:*
Benjamin Munson	[redacted]	PD/PI
Matthew Winn	[redacted]	Consultant
JEFFRY SIMPSON	[redacted]	Consultant
Andrew Oxenham	[redacted]	Co-Investigator
Peggy Nelson	[redacted]	Co-Investigator
Evelyn DaviesVenn	[redacted]	Consultant
Molly Babel	[redacted]	Consultant

APPLICATION FOR FEDERAL ASSISTANCE
SF 424 (R&R)

3. DATE RECEIVED BY STATE	**State Application Identifier**

1. TYPE OF SUBMISSION*

❍ Pre-application ● Application ❍ Changed/Corrected Application

4.a. Federal Identifier

b. Agency Routing Number

2. DATE SUBMITTED

Application Identifier
PRF 962034 NIH

c. Previous Grants.gov Tracking Number

5. APPLICANT INFORMATION

Organizational DUNS*: [redacted]

Legal Name*: REGENTS OF THE UNIVERSITY OF MINNESOTA
Department:
Division:
Street1*: [redacted]

Person to be contacted on matters involving this application
Prefix: First Name*: Victoria Middle Name: Last Name*: Troxler Suffix:
Position/Title: Grants Administrator
Street1*: [redacted]

6. EMPLOYER IDENTIFICATION NUMBER *(EIN) or (TIN)** [redacted]

7. TYPE OF APPLICANT* H: Public/State Controlled Institution of Higher Education

Other (Specify):
Small Business Organization Type ❍ Women Owned ❍ Socially and Economically Disadvantaged

8. TYPE OF APPLICATION*

● New ❍ Resubmission
❍ Renewal ❍ Continuation ❍ Revision

If Revision, mark appropriate box(es).
❍ A. Increase Award ❍ B. Decrease Award ❍ C. Increase Duration
❍ D. Decrease Duration ❍ E. Other *(specify)* :

Is this application being submitted to other agencies?* ❍Yes ●No What other Agencies?

9. NAME OF FEDERAL AGENCY*
National Institutes of Health

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER
TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT*
Race, Ethnicity, and Speech Intelligibility in Normal Hearing and Hearing Impairment

12. PROPOSED PROJECT
Start Date* Ending Date*
06/01/2019 05/31/2021

13. CONGRESSIONAL DISTRICTS OF APPLICANT
[redacted]

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix: First Name*: Benjamin Middle Name: R Last Name*: Munson Suffix:

Position/Title: Professor

Organization Name*: [redacted]

Division:

Street1*: [redacted]

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested* [redacted].00

16.IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?*

a. YES ❍ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ● PROGRAM IS NOT COVERED BY E.O. 12372; OR

❍ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

● I agree*

** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.*

18. SFLLL or OTHER EXPLANATORY DOCUMENTATION File Name:

19. AUTHORIZED REPRESENTATIVE

Prefix: First Name*: Kevin Middle Name: Last Name*: McKoskey Suffix:

Position/Title*: Director, Sponsored Projects Administration

Organization Name*: [redacted]

Signature of Authorized Representative*

April Coon

Date Signed*

10/15/2018

20. PRE-APPLICATION File Name:

21. COVER LETTER ATTACHMENT File Name:

424 R&R and PHS-398 Specific
Table Of Contents

OMB Number: 4040-0010
Expiration Date: 10/31/2019

Project/Performance Site Location(s)

Project/Performance Site Primary Location

○ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: [redacted]

Additional Location(s)

File Name:

Tracking Number: GRANT12729780

Funding Opportunity Number: PA-18-489. Received Date: 2018-10-15T15:01:25.000-04:00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED Other Project Information

1. Are Human Subjects Involved?* ● **Yes** ❍ **No**

1.a. If YES to Human Subjects

Is the Project Exempt from Federal regulations? ❍ Yes ● No

If YES, check appropriate exemption number: _ 1 _ 2 _ 3 _ 4 _ 5 _ 6 _ 7 _ 8

If NO, is the IRB review Pending? ● **Yes** ❍ **No**

IRB Approval Date:

Human Subject Assurance Number 00000312

2. Are Vertebrate Animals Used?* ❍ **Yes** ● **No**

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ❍ Yes ❍ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. Is proprietary/privileged information included in the application?* ❍ **Yes** ● **No**

4.a. Does this project have an actual or potential impact - positive or negative - on the environment?* ❍ **Yes** ● **No**

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ❍ Yes ❍ No

4.d. If yes, please explain:

5. Is the research performance site designated, or eligible to be designated, as a historic place?* ❍ **Yes** ● **No**

5.a. If yes, please explain:

6. Does this project involve activities outside the United States or partnership with international collaborators?* ● **Yes** ❍ **No**

6.a. If yes, identify countries: Canada

6.b. Optional Explanation:

	Filename
7. Project Summary/Abstract*	AVGrant_R21_ProjectSummaryAbstract_Final.pdf
8. Project Narrative*	AVGrant_R21_ProjectNarrative_Final.pdf
9. Bibliography & References Cited	AVGrant_R21_Bibliography_Final.pdf
10.Facilities & Other Resources	AVGrant_R21_Facilities_Final.pdf
11.Equipment	AVGrant_R21_Equipment_Final.pdf

Tracking Number: GRANT12729780

Funding Opportunity Number: PA-18-489. Received Date: 2018-10-15T15:01:25.000-04:00

Project Summary/Abstract

Hearing impairment (HI) affects a large proportion of older adults: 25% of 65-74 year olds, and 50% of people 75 and older have a HI that is sufficiently severe to be disabling [36,42]. The primary complaint of individuals with HI is difficulty understanding speech. Suboptimal speech communication by people with HI is a likely reason why they suffer from broader behavioral and physical health problems [35,53]. Understanding the factors that affect speech perception by people with HI, and finding methods to overcome the speech perception difficulties that these individuals face, is of great societal importance. Because of changing US demographics, communication between older individuals with HI and younger individuals—including those in caregiving and service-delivery roles—is increasingly likely to be between individuals of different races and ethnicities [44,54]. This presents a potential unique problem to individuals with HI. Research has shown that a talker's speech can become less intelligible to normal hearing (NH) individuals when they become aware of a talker's race or ethnicity by seeing a picture of the talker [6,37,48]. Given ongoing demographic changes, these findings have potentially profound implications for our understanding of speech perception by older adults with HI, as their communication with younger individuals is likely to be across lines of race and ethnicity. This may provide an additional challenge to speech perception beyond the challenge posed by the sensory loss itself. The proposed project seeks to remove two barriers to conducting large-scale studies of effects of race and ethnicity on speech perception by older adults with HI. One barrier is that there are no existing audiovisual corpora of speech stimuli that are produced by ethnically and racially diverse individuals. In specific aim 1, we will build a new corpus of audiovisual speech stimuli produced by individuals from diverse races and ethnicities. This corpus will include both standard-of-care sentences used in research on HI [26], and a new set of sentence materials designed specifically for this project. This corpus will be made available to the public at the conclusion of funding. The second barrier is that the previous studies have not determined the specific mechanism that explains why talker race and ethnicity affect speech intelligibility. In specific aim 2, we will use stimuli from specific aim 1 in a series of intelligibility experiments with younger listeners with NH, older listeners with NH, and older listeners with HI, using both behavioral and eye-tracking responses. We will also collect information on individuals' attitudes toward individuals of different races and ethnicities, as well as the ethnic and racial diversity in their peer groups. Results from this specific aim will help us better understand the mechanisms that underlie effects of race and ethnicity on speech intelligibility, and whether the speech perception of older adults with HI is disproportionately poorer in interactions with racially and ethnically diverse interlocutors. Given ongoing demographic changes and the high incidence of hearing impairment, these results will be of high public health relevance.

Project Narrative

Recent research has shown that speech intelligibility can change when a listener becomes aware of a talker's race and ethnicity. This project will build a corpus of audiovisual speech stimuli produced by ethnically and racially diverse talkers, determine the locus of effects of talker race and ethnicity effects on speech intelligibility, and determine the extent to which talker race and ethnicity affect speech perception by older listeners with hearing impairment (HI). Given the large percentage of the population that has HI (50% of people over 75), and the large and growing percentage of the US population of the US that is Latinx (~17%) and non-white (~37%), these findings are of great public health relevance.

Physical Facilities:

Dr. Munson has a 270 ft2 private office in 205A Shevlin Hall. This space has locked file cabinets and a computer that is used for data analysis and writing. Dr. Munson's laboratory is a 666 ft² space in 5 Shevlin Hall. In addition, Dr. Munson has access to the [redacted] Multisensory Perception (MSP) lab, which has facilities to collect perception data.

Intellectual Environment:

The Center for Translational and Applied Sensory Science (CATSS) is a collective of researchers interested in sensory perception and sensory loss. PI Munson and consultants Winn and Davies-Venn are members of CATSS; co-I Oxenham is co-scientific director, and co-I Nelson is executive director. CATSS houses the MSP lab, in which data collection will take place, along with space for working-group meetings. It also hosts periodic colloquia, and opportunities for members to present research in progress. Many CATSS researchers not named in this application work on issues that are peripherally related to this project, such as work on visual perception, virtual reality, and visual impairment. In short, CATSS provides an intellectual environment that will support this work as it progresses. Moreover, CATSS will provide a rich and supportive intellectual environment for the TBA postdoctoral fellow who will be employed on this project. CATSS provides a potential resource for additional staff support, as CATSS is home to an NSF-funded NRT training program in sensory science. Components of the project described in this application will be of interest to trainees in that program.

The [redacted] has numerous services for statistical consulting and collaboration, including both free and fee-for-service consultation. The University of Minnesota's School of Statistics is housed in the same college as PI Munson, and he has used these services previously to develop novel statistical analyses for complex research designs.

Other Staff Support Mechanisms: A potential source of additional staff support is from the University of Minnesota's Undergraduate Research Opportunities Program (UROP). UROP grants provide undergraduate students with 15 weeks of funding to work on research projects. PI Munson has advised numerous UROP grants, and anticipates UROP being a source of additional staff support for this project. University of Minnesota also has two mechanisms to engage under-represented groups in research: the Multicultural Summer Research Program (MSROP), and the Trio/McNair scholars program. PI Munson has advised students in both of these programs previously, and has already reached out to the MSROP and Trio/McNair leadership to recruit students for Summer 2019 and Summer 2020 to work on the project described in this application.

Liaisons to Diverse Twin Cities Communities: One important goal of this project is to recruit a diverse population of talkers in specific aim 1, and a diverse group of listeners in specific aim 2. The University of [redacted] Urban Outreach and Research Center (UROC) facilitates connections between university researchers and diverse communities in the Twin Cities metropolitan areas. Moreover, the University [redacted] collaborates with a number of agencies and organizations who serve racially and ethnically diverse communities. These resources will help us to achieve our goal of recruiting a diverse group of participants.

Equipment

All of the equipment needed for this grant is housed in PI Munson's laboratory, and in the University of [redacted] Multisensory Perception (MSP) Laboratory, which is located in a building adjacent to the one that houses PI Munson's lab.

Dr. Munson's laboratory is equipped with an 8' x 8' double-walled sound-treated room that is configured to collect perception data, and to record audio-visual stimuli. The sound-treated room has a touch-screen monitor, a boom microphone, professional-grade lighting, and the capacity to present sounds either in a soundfield (in either mono or stereo) or over headphones. Dr. Munson's lab also has a separate area for data analysis, a separate area for data collection via standardized tests (i.e., not requiring a sound-treated room), and numerous locked cabinets for storing hard copies of data. Dr. Munson's laboratory will be used to record audiovisual stimuli for specific aim 1, and for data analysis for both specific aims. Dr. Munson's lab is equipped with two GigE Prosilica 680 cameras with Kowa C Mount lenses to make high-resolution, high-frame rate video recordings. These are synched with professional-grade microphones and solid-state recorders for making high-quality audio recordings.

Dr. Munson's laboratory is equipped with 4 desktop computers that are replaced on a four-year cycle. These have the software needed for this project (R, Praat, Avidemux).

The MSP Lab has a 150 ft2 sound-treated room with a 48-speaker surround-sound array, and with the capability to project video images on three walls. The room is equipped with a Tobii T60 XL eye-tracker, which will be used to collect eye-tracking data. The MSP will be used to collect the speech-perception data for specific aim 2 of this project.

The MSP has 4 computers, and is in the process of purchasing many others as their space develops.

Dr. Munson has access to a private, secured server that houses data and materials for his research projects. The server can be accessed only by people that Dr. Munson grants access to, including individuals at other sites. This server will be used to house the data for this project.

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: First Name*: Benjamin Middle Name R Last Name*: Munson Suffix:

Position/Title*: Professor

Organization Name*: [redacted]

[redacted]

Credential, e.g., agency login: [redacted]

Project Role*: PD/PI Other Project Role Category:

Degree Type: Degree Year:

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Munson.pdf

Attach Current & Pending Support: File Name:

Tracking Number: GRANT12729780 Funding Opportunity Number: PA-18-489 . Received Date: 2018-10-15T15:01:25.000-04:00

PROFILE - Senior/Key Person

Prefix: First Name*: Matthew Middle Name Brandon Last Name*: Winn Suffix:

Position/Title*: Assistant Professor
Organization Name*: [redacted]

Phone Number*: [redacted] Fax Number:

E-Mail*: [redacted]

Credential, e.g., agency login [redacted]

Project Role*: Consultant Other Project Role Category:

Degree Type: AUD,PHD,BA Degree Year: 2010,2011,2005

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Winn.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: JEFFRY Middle Name Alan Last Name*: SIMPSON Suffix:

Position/Title*: Professor
Organization Name*: [redacted]

Phone Number*: [redacted] Fax Number:

E-Mail*: [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Consultant Other Project Role Category:

Degree Type: PHD,AB Degree Year: 1986,1981

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Simpson.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Andrew Middle Name J. Last Name*: Oxenham Suffix:

Position/Title*: Prof.
Organization Name*: [redacted]

Phone Number*: [redacted]

Credential, e.g., agency login [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PHD Degree Year: 1995

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Oxenham.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Peggy Middle Name B Last Name*: Nelson Suffix:

Position/Title*: Professor
Organization Name*: [redacted]

E-Mail*: [redacted]

Credential, e.g., agency login: [redacted]

Project Role*: Co-Investigator Other Project Role Category:

Degree Type: PHD,MA,BA Degree Year: 1991,1982,1974

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Nelson.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Evelyn Middle Name EMO Last Name*: DaviesVenn Suffix:

Position/Title*: Assistant Professor
Organization Name*: [redacted]
Zip / Postal Code*: [redacted]

Phone Number*: [redacted]

Credential, e.g., agency login [redacted]

Project Role*: Consultant Other Project Role Category:

Degree Type: AUD,PHD,MS,BA Degree Year: 2005,2010,2004,2002

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Davies-Venn.pdf

Attach Current & Pending Support: File Name:

PROFILE - Senior/Key Person

Prefix: First Name*: Molly Middle Name Last Name*: Babel Suffix:

Position/Title*: Associate Professor
Organization Name*: University of British Columbia
Department: Linguistics
Division:
Street1*: 2613 West Mall
Street2:
City*: Vancouver
County:
State*:
Province: British Columbia
Country*: CAN: CANADA
Zip / Postal Code*: V6T 1Z4

Phone Number*: 1 604 822 2976 Fax Number:

E-Mail*: molly.babel@ubc.ca

Credential, e.g., agency login: mollybabel

Project Role*: Consultant Other Project Role Category:

Degree Type: PhD Degree Year: 2009

Attach Biographical Sketch*: File Name: AVGrant_R21_Biosketch_Babel.pdf

Attach Current & Pending Support: File Name:

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Benjamin Ray Munson, Jr.

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Professor and Chair

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
State University of New York, Buffalo, NY	B.A.	1992	Linguistics
University of California, Los Angeles, CA	(Graduate Course-work)	1992-1994	Linguistics
The Ohio State University, Columbus, OH	M.A.	1997	Speech-Language Pathology
The Ohio State University, Columbus, OH	Ph.D.	2000	Speech and Hearing Science

A. Personal Statement

In my 18+ years [redacted] I have developed a diverse research program that examines the interplay between speech production and speech perception in individuals with communication disorders. Most relevant to this grant, my previous work has included adults with hearing impairment (Munson et al., 2003; Collison, Munson, & Carney, 2004; Munson & Nelson, 2005) and a recent grant that included children with hearing impairment (NIH grant R01 DC002932). My research has focused on the interplay between 'bottom-up' knowledge of sounds' articulatory and auditory characteristics, and 'top-down' knowledge of how sounds pattern in words, and how speech sound variation conveys socially meaningful information about talkers. The latter topic is central to this grant: how do listeners' knowledge and expectations of socially meaningful variation affect speech communication by individuals with hearing impairment? This topic is vital to our understanding of impaired communication. Communication across lines of race and ethnicity is fast becoming the norm in the US, and there is growing evidence that these social factors provide an additional challenge to communication that has not been considered in previous research. This grant will develop a valuable resource to study this topic: a corpus of audio-visual speech produced by racially and ethnically diverse talkers. That resource builds on my expertise in corpus development (Beckman, Plummer, Munson, & Reidy, 2017). It will be of great use to my future research on this topic, and to the community of individuals who study hearing loss, amplification, and speech perception. Moreover, this grant will use this resource to study speech intelligibility in individuals with and without hearing impairment, to better understand the scope and nature of effects of talker ethnicity and race on speech perception.

B. Positions and Honors

Positions

Department of Speech-Language-Hearing Sciences (renamed from Department of Communication Disorders, 7/2004), University of Minnesota, Minneapolis, MN

Assistant Professor, 8/28/2000-8/27/2006.
Associate Professor with Tenure, 8/28/2006-8/26/2012
Full Professor with Tenure, 8/27/2012-6/10/2018
Full Professor with Tenure and Chair, 6/11/2018-current

Honors

1. Young Investigator Travel Award, Acoustical Society of America Committee on Women in Acoustics, 2002
2. Students' Choice Outstanding Faculty Member of the Year, University of Minnesota College of Liberal Arts Student Board, 2002-2003.
3. Editor's Award for Outstanding Article in *Journal of Speech Language, and Hearing Research* (Hearing section). Co-awarded to Elizabeth Collison, Benjamin Munson, and Arlene E. Carney, 2004.
4. Award for Early Career Contributions in Research, American Speech-Language-Hearing Association, 2005.
5. Arthur "Red" Motley Outstanding Teaching Award, University of Minnesota College of Liberal Arts, 2006
6. McKnight Foundation Presidential Fellowship, University of Minnesota Graduate School, 2006-2009.
7. John Erskine Fellowship, University of Canterbury, Christchurch, New Zealand, 2008
8. Fellow, Acoustical Society of America, 2011
9. Visiting Faculty Fellowship, University of Newcastle upon Tyne, 2011
10. Fellow, American Speech-Language-Hearing Association, 2013
11. Visiting Scholar, Center for Advanced Studies, Ludwig-Maximillians University, Munich, 2014
12. Visiting Scholar, Laboratoire Parole et Langage, Aix-Marseille University, September, 2013, November, 2015
13. Visiting Scholar, University of Hong Kong, June, 2016

Other Experience and Professional Memberships

Member of:	American Speech-Language-Hearing Association, Acoustical Society of America, Linguistic Society of America
2005-2007	Associate Editor, *Journal of Speech, Language, and Hearing Research*
2010-2013	Chair, Speech Communication technical committee, Acoustical Society of America
2011-2014	Associate Editor, *Journal of the Acoustical Society of America*
2014-2017	Member, Language and Communication (LCOM) review panel, Center for Scientific Review, National Institutes of Health
2011-current	Chair, University of Minnesota Institutional Review Board (IRB), Human Subjects' Protection Program, Panel J (Faculty Social and Behavioral Science Research).

C. Contributions to Science

1. Social and other Top-Down Influences on Speech Perception

Speech perception involves both bottom-up and top-down process. My first scientific contribution has been to examine top-down influences on speech perception. The focus of much of this work has been on how social information affects speech perception, which is the topic of the current proposal.

Evans, K., Munson, B., & Edwards, J. (2018). Does speaker race affect the assessment of children's speech accuracy? A comparison of speech-language pathologists and clinically untrained listeners. *Language, Speech, and Hearing Services in Schools*. E-Publication ahead of print, doi:10.1044/2018_LSHSS-17-0120. PMID: 29971346

Munson, B., & Nelson, P.B. (2005). Phonetic identification in quiet and in noise by listeners with cochlear implants. *Journal of the Acoustical Society of America, 118*, 2607-2617. PMID: 16266181

Munson, B., Jefferson, S.V., & McDonald, E.C. (2006). The influence of perceived sexual orientation on fricative identification. *Journal of the Acoustical Society of America, 119*, 2427-2437. PMID: 16642855

Munson, B. (2011). The Influence of Actual and Imputed Talker Gender on Fricative Perception, Revisited. *Journal of the Acoustical Society of America, 130*, 2631-2634. PMID: 22087888

2. Sexuality and Phonetic Variation across the Lifespan

A key fact about speech is that it varies along multiple dimensions. My second scientific contribution has been to examine how listeners convey one socially meaningful variable, sexuality, through phonetic variation. Sexuality is a particularly interesting social variable to examine because one's sexuality is typically not established until late in adolescence. Hence, the acquisition of this speech style a potentially illuminating case study of late-life language acquisition. My studies have shown that there is a distinctive speech style used by a subset of self-identified gay men and lesbian women, and that this style is salient enough to allow naïve listeners to identify a person's sexuality from content-neutral speech. Rudiments of this speech style can be seen in children with non-canonical patterns of gender identity as young as five years of age.

Mack, S., & Munson, B. (2012). The influence of /s/ quality on ratings of men's sexual orientation: Explicit and implicit measures of the 'gay lisp' stereotype. *Journal of Phonetics, 40*, 198–212.

Munson, B. (2007). The acoustic correlates of perceived sexual orientation, perceived masculinity, and perceived femininity. *Language and Speech, 50*, 125-142. PMID: 17518106

Munson, B., Crocker, L., Pierrehumbert, J., Owen-Anderson, A., & Zucker, K. (2015). Gender typicality in children's speech: A comparison of the speech of boys with and without gender identity disorder. *Journal of the Acoustical society of America, 137*. PMID: 25920850

Munson, B., McDonald, E.C., DeBoe, N.L., & White, A.R. (2006). Acoustic and perceptual bases of judgments of women and men's sexual orientation from read speech. *Journal of Phonetics, 34*, 202-240.

3. Lexical Influences on Phonological Development and Disorders

Traditional models of phonological development posited that knowledge of the sound structure influences vocabulary development only insomuch as early perception and production impairments might impede word-learning. My work has shown that expansion in the lexicon has a top-down influence on phonological development, such that children with larger vocabularies are better able to make implicit generalizations about the sound structure of language. These relationships hold across children with a variety of vocabulary sizes due to variation in age and in overall language ability.

Munson, B. (2001). Phonological pattern frequency and speech production in children and adults. *Journal of Speech, Language, and Hearing Research, 44*, 778-792. PMID: 11521771

Edwards, J., Beckman, M.E., & Munson, B. (2004). The interaction between vocabulary size and phonotactic probability effects on children's production accuracy and fluency in nonword repetition. *Journal of Speech, Language, and Hearing Research, 47*, 421-436. PMID: 15157141

Munson, B., Edwards, J., & Beckman, M.E. (2005). Relationships between nonword repetition accuracy and other measures of linguistic development in children with phonological disorders. *Journal of Speech, Language, and Hearing Research, 48*, 61-78. PMID: 15938060

Munson, B., Kurtz, B.A., & Windsor, J. (2005). The influence of vocabulary size, phonotactic probability, and wordlikeness on nonword repetitions of children with and without specific language impairment. *Journal of Speech, Language, and Hearing Research, 48*, 1033-1047. PMID: 16411794

4. Lexical Influences on Phonetic Variation

Traditional models of phonological knowledge posited a strict modular demarcation between the size and composition of the mental lexicon and knowledge of the sound structure of language. My work in this area has shown that lexical characteristics of words (specifically, their frequency of use and their similarity to other known real words) affect their phonetic structure. Words that are frequently used and which are dissimilar to other real words are produced with a less distinct articulation than words with the opposite characteristics. This line of research has important implications for models of speech production.

Munson, B., & Solomon, N.P. (2004). The effect of phonological neighborhood density on vowel articulation. *Journal of Speech, Language, and Hearing Research, 47*, 1048-1058. PMID: 15605431

Munson, B. (2007). Lexical access, lexical representation, and vowel articulation. In J. Cole & J. Hualde (Eds.), *Laboratory Phonology 9* (p. 201-228). New York: Mouton de Gruyter.

Watson, P., & Munson, B. (2008). Parkinson's disease and the effect of lexical factors on vowel articulation. *Journal of the Acoustical Society of America, 5*, EL291-EL295. PMID: 19045680

Yoneyama, K., & Munson, B. (2017). The influence of lexical characteristics and talker accent on the recognition of English words by speakers of Japanese. *Journal of the Acoustical Society of America, 141*, 1308-1320. PMID: 28253637

5. Improving Methods for Assessing Phonetic Development

The most commonly used tool to study speech sound development is phonetic transcription. Transcription is also used in almost every assessment tool that has been developed for assessing speech sound disorders. Phonetic transcription has the weakness that it is poorly equipped to assess variation within phonemic categories. Research using articulatory and acoustic measures has shown that such variation is pervasive. My research has developed a variety of novel perceptual measures for assessing continuous variation. This work has shown that such measures are sensitive to cross-linguistic differences in acquisition. They also reveal effects of clinical experience in speech-language pathology on ratings.

Munson, B., Edwards, J., Schellinger, S.K., Beckman, M.E., & Meyer, M.K. (2010). Deconstructing phonetic transcription: covert contrast, perceptual bias, and an extraterrestrial view of *Vox Humana*. *Clinical Linguistics and Phonetics, 24*, 245-260. PMID: 20345255

Li, F., Munson, B., Edwards, J., Yoneyama, K., & Hall, K.C. (2011). Language specificity in the perception of voiceless sibilant fricatives in Japanese and English: Implications for cross-language differences in

speech-sound development. *Journal of the Acoustical Society of America, 129*, 999-1011. PMID: 21361456

Munson, B., Johnson, J., & Edwards, J. (2012). The role of experience in the perception of phonetic detail in children's Speech: a comparison of speech-language pathologists with clinically untrained listeners. *American Journal of Speech-Language Pathology, 24*, 124-139. PMID: 22230182

Schellinger, S.K., Munson, B., & Edwards, J. (2017). Gradient Perception of Children's Productions of /s/ and /θ/: A Comparative Study of Rating Methods. *Clinical Linguistics and Phonetics, 31*, 80-103. PMID: 27552446

A full set of publications can be found at https://scholar.google.com/citations?user=WG_AOVIAAAAJ&hl=en

D. Research Support

Completed

NIH Grant R01 DC002932 Munson (MPI), 4/1/2011-3/31/2018 (multi-PI grant. J. Edwards, M. Beckman, B. Munson, MPIs, David Kaplan, co-I)

Longitudinal Study of Lexical and Phonological Development

This study examines the relationships among components of phonological knowledge (including the ability to perceive speech sounds in challenging listening tasks, the ability to robustly differentiate among speech sounds in production, and the ability to make inferences about how sounds function in the language being acquired) and lexical acquisition in children with a wide range of vocabulary sizes, where size varies for different reasons across groups. Specifically, this is a longitudinal study from 30 to 60 months of age of approximately 200 children with a wide variety of initial vocabulary sizes resulting from a range of advantages or deficits in the types of phonological knowledge that support word learning. The specific research question addressed is: what are the developmental relationships among vocabulary growth and three types of phonological knowledge (speech production knowledge, speech perception knowledge, and higher-level categorical knowledge) for children with normal hearing from middle-SES and low-SES families, and for children with cochlear implants (CIs)? The study also includes a statistical modeling component to determine optimal interventions for children with small-sized vocabularies. Structural equation modeling, based on data from this rich longitudinal sample, will allow us to test what interventions might be most effective to increase vocabulary for these different groups of children. Ultimately, the knowledge obtained from this study will enable us to develop efficacious and targeted early interventions for young children with atypically small vocabularies

NSF Grant BCS0729277 Munson (PI) 1/1/08-12/31/2010

NSF DHB/Collaborative Research: Using machine learning to model the interplay of production dynamics and perception dynamics in phonological acquisition

The goal of this collaborative research grant (including components at the lead institution, Ohio State University [Mary E. Beckman, PI, Eric Fosler-Lussier co-I] and University of Wisconsin-Madison [Jan Edwards] is to apply acoustic models that are currently being developed for robust Automatic Speech Recognition (ASR) will be applied to a large multi-language database to explore how cognitive representations relevant to speech production and perception in any given speech community come to be internalized by normally developing children.

NSF Grant BCS074644 Munson (PI) 1/1/08-12/31/2009

Supporting Young Investigator Travel to the Eleventh Conference on Laboratory Phonology

Through this grant, the NSF provided funding for ten early-career scholars, including students, to attend the Eleventh Conference on Laboratory Phonology. Travel grant applications were evaluated by a committee comprising early-career investigators from U.S. and New Zealand universities. They were disbursed by the University of Minnesota.

NIH Grant R03 DC005702 Munson (PI) 6/1/03-5/31/2007

Speech Production in Phonological Impairment

The overall goal of this project is to assess the extent to which lexical representation and processing (referred to from here forward as lexical skills), phonological representation and processing (phonological skills), and the linking between them (linking skills) are compromised in children with phonological impairments (PhI) aged 4

to 7. Three experiments are proposed to determine the locus of phonological impairment. In addition, measures of lexical, phonological, and linking skill will be related to phonological patterns in spontaneous speech and single-word naming, to assess the extent to which these skills predict error patterns of children with PhI.

BIOGRAPHICAL SKETCH

NAME: Matthew Brandon Winn

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Assistant Professor of Speech-Language-Hearing Sciences

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Delaware	B.A.	8/2005	Psychology, Philosophy
University of Maryland College Park	Au.D.	5/2010	Clinical Audiology
Veterans Affairs (fourth-year audiology residency)		7/2010	Clinical Audiology
University of Maryland College Park	Ph.D.	11/2011	Hearing and Speech Sciences
University of Wisconsin-Madison		8/2015	Communication Sciences and Disorders

A. Personal Statement

I am an audiologist and hearing scientist with training in speech science and linguistics. My research focuses on speech perception and how it is affected by hearing loss. In my lab we use measures of eye tracking and pupillometry to measure perception of speech and the effort involved in listening.
I am interested in measuring various effects of hearing loss that are not well described by conventional testing, including listening effort, adjustment to different talker styles, reliance on non-auditory cues, spectral resolution, perceptual gradiency and binaural hearing. Additionally, I have developed open-source solutions for speech stimulus generation for experiments involving phonetic categorization and cue weighting, as well as analysis tools for pupillometry. My goal is to make a positive contribution to auditory science, the cognitive sciences, and the care of audiology patients. I aim to embody the mission of the NIH in terms of mentoring students in the area of bridging clinical practice and research, as well as incorporating a multidisciplinary approach to speech, language and hearing sciences.

B. Positions and Honors

Positions:

7/2009 – 2/2012	Clinical audiologist, Washington D.C. Veterans Affairs Medical Center
4/2012 – 8/7/2015	Postdoctoral researcher, Waisman Center, Univ. of Wisconsin-Madison
6/2013 – 8/7/2015	Research associate, Department of Surgery, Univ. of Wisconsin-Madison
9/2015 – 8/2018	Assistant Professor, Speech & Hearing Sciences, Univ. of Washington
8/2015 – *present*	Assistant Professor, Speech-Language-Hearing Sciences, Univ. of Minnesota

Professional memberships:

Acoustical Society of America
Association for Research in Otolaryngology
American Auditory Society

Honors:
2010, 2011: Pre-Doctoral Training Grant, Center for Comparative Evolution and Biology of Hearing
2010; Mentored Doctoral Student Research Poster grant, American Auditory Society
2010, 2011: Distinguished Teaching Award, Univ. of Maryland Center for Teaching Excellence
2011: Dean's Scholar Mentorship Award, Univ. of Maryland College of Behavioral Social Sciences
2011: Student travel award, Conference on Implantable Auditory Prostheses
2013: Student travel award, Conference on Implantable Auditory Prostheses
2014: Young Investigator award, Conference on Objective Measures in Auditory Implants

C. Contribution to Science

1). Measuring listening effort using pupillometry

The pupillary response is a sensitive metric of listening effort that is driven by changes in auditory spectral resolution and linguistic processing. Specifically, the pupil shows greater dilation as effort increases, and this measurement can capture dynamics of effort as they happen over time.

I am part of a small group of investigators worldwide who use pupillometry to assess listening effort. In a recent international workshop on pupillometry in Amsterdam, I joined with a small number of others to initiate a joint effort to collect our shared experiences and contribute a "best-practices" paper to raise standards and avoid duplicate work of pupillometry research in the field of hearing science.

The influence of this work can be described in two categories. First, it emphasizes the importance of listening effort as complementary to traditional intelligibility scores. In light of considerable literature demonstrating the public health and economic impact of elevated listening effort in people with hearing impairment, the scope of this work extends beyond basic auditory processing. Second, the nature of pupillometry as a time-varying measurement means that sentence processing can be measured as it unfolds over time, which is a novel contribution in the field of clinical hearing science (where speech perception measurements are almost uniformly recorded *after* perception has taken place. By capitalizing on this aspect of the measurement, I have shown that the timing of sentence comprehension can be delayed in people with cochlear implants, despite excellent intelligibility scores.

The importance of this work is that delayed or disrupted language processing might not show up in intelligibility scores, but still could play a major role in the functional performance of a listener who has hearing impairment. In all of these studies, my role has been the primary investigator.

a. **Winn, M.B.**, Edwards, J.R., and Litovsky, R.Y. (2015). The impact of auditory spectral resolution on listening effort revealed by pupil dilation. *Ear and Hearing,* 36(4):e153-65.
b. **Winn, M.B.** (2016) Rapid release from listening effort resulting from semantic context, and effects of spectral degradation and cochlear implants. *Trends in Hearing*, 20, 1-17.
c. **Winn, M.B.**, Wendt, D., Koelewijn, T., Kuchinsky, S. Best practices in using pupillometry to measure listening effort: an introduction for those who want to get started**.** *In Press, Trends in Hearing.*

2. Phonetic cue weighting and how it is affected by hearing loss

My earliest and ongoing publications address the manner in which people perceive speech sounds under various conditions of impaired or simulated impaired hearing. The central finding of this branch of work is that people with hearing impairment can rely on acoustic cues to identify speech sounds in ways that differ from patterns observed in people who have normal hearing. Specifically, people who use cochlear implants show greater reliance upon temporal aspects of speech sounds and relatively less reliance on spectral components, consistent with the nature of implant speech signal processing.

The importance of this work is that it demonstrates the fact that patterns of speech cue perception and weighting as measured in people with normal hearing do not necessarily carry over to populations of people with hearing impairment. Because of the nature of speech as a complex and multi-dimensional

signal, there are many opportunities to mistake performance in one domain (i.e. temporal) as performance in another domain (i.e. spectral).

The philosophy behind this work has spawned a new line of research (by myself and other labs) that uses phonetic cue weighting as a diagnostic outcome measure or a predictor of other auditory abilities. In all of these studies, my role has been the primary investigator.

a. **Winn, M.B.,** Chatterjee, M., & Idsardi, W.J. (2013). The roles of voice onset time and F0 in stop consonant voicing perception: Effects of masking noise and low-pass filtering. *Journal of Speech, Language and Hearing Research,* 56, 1097-1107.
b. **Winn, M.B.,** Rhone, A.E., Chatterjee, M., & Idsardi, W.J. (2013). Auditory and visual context effects in phonetic perception by normal-hearing listeners and listeners with cochlear implants. *Frontiers in Psychology: Auditory Cognitive Neuroscience*, 4, article 824, 1-13.
c. **Winn, M.B.**, Won, J.H., Moon, I.J. (2016). Assessment of spectral and temporal resolution in cochlear implant users using psychoacoustic discrimination and speech cue categorization. *Ear and Hearing*, 37(6), e377– e390.
d. Kapnoula, E., **Winn**, M.B., Kong, E.J., Edwards, J., McMurray, B. (2017) Evaluating the sources and functions of gradiency in phoneme categorization: An individual differences approach. *Journal of Experimental Psychology: Human Perception and Performance*, 43, 1594-1611. doi: 10.1037/xhp0000410

3). Measuring spectral resolution in cochlear implant patients using speech sounds

Stemming from the aforementioned work on phonetic cue weighting, this branch of research focuses on speech cues that are specifically spectral in nature (i.e. are cued by frequency differences rather than timing or overall amplitude differences). This decision was made to specifically tailor experiments to the needs and abilities of people who use cochlear implants, which are devices that restore hearing, albeit with particular challenges in spectral resolution. By developing a test of spectral phonetic cue perception, this line of work has produced a simple yet powerful diagnostic test of functional performance that bears relationship to speech perception without relying on abstract non-linguistic psychophysical stimuli, and while still avoiding the historical confounds of using multi-dimensional speech stimuli that confound the measurement of a single auditory dimension.

The importance of this work is that the paradigm used to test functional spectral resolution can be used to evaluate new sound processing strategies in cochlear implants and hearing aids. Importantly, the test is sensitive specifically to the domain that is the target of improvement in cochlear implant technology.

a. **Winn, M.B.** & Litovsky, R.Y. (2015) Using speech sounds to test functional spectral resolution in listeners with cochlear implants. *Journal of the Acoustical Society of America*, 137, 1430-1442.
b. Kong, Y.-Y., **Winn, M.B.**, Poellmann, K., Donaldson, G. (2016). Discriminability and perceptual saliency of temporal and spectral cues for final fricative consonant voicing in simulated cochlear-implant and bimodal hearing. Trends in Hearing, 20, 1-15.
c. DiNino, M., Wright, R., **Winn, M.B.**, Bierer, J.A. (2016). Vowel and consonant confusion patterns resulting from spectral manipulations in vocoded stimuli designed to replicate poor electrode-neuron interfaces in cochlear implants. Journal of the Acoustical Society of America, 140, 4404–4418.

4). Development of freely available software and other resources

Most of the aforementioned research contributions depend on the generation of controlled acoustic stimuli that sound like natural speech and reflect the complexity and cues important to natural speech, and are yet controlled with precision sufficient for rigorous auditory experimentation. My contribution has been to develop software that enables an experimenter to generate such speech sounds or simulating cochlear implants using a freely available platform (Praat). This software includes numerous options to customize sound output in ways that are valuable to auditory scientists but often

extremely tedious to control without extensive experience in speech acoustics and programming. By wrapping these experiences into a user-friendly program, I have produced a tool that has been used at several universities to test perception of speech sounds in a finely controlled fashion.

The software is available at:
http://www.mattwinn.com/praat.html
and the specific speech manipulation tools are at:
http://www.mattwinn.com/praat.html#formantContinuum
http://www.mattwinn.com/praat.html#votContinuum
http://www.mattwinn.com/praat.html#fricativeContinuum
http://www.mattwinn.com/praat.html#durationContinuum

a. **Winn, M.B.** & Litovsky, R.Y. (2015) Using speech sounds to test functional spectral resolution in listeners with cochlear implants. *Journal of the Acoustical Society of America*, 137, 1430-1442.
b. Stilp, C.E., Anderson, P.W., **Winn, M.B.** (2015) Predicting contrast effects following reliable spectral properties in speech perception. *Journal of the Acoustical Society of America, 137*, 3466-3476.

Complete List of Published Work: http://www.ncbi.nlm.nih.gov/pubmed/?term=matthew+B+winn

D. Research Support

Ongoing Research Support

R01 DC 017114 8/2018 – 7/2023
Listening effort in cochlear implant users
The goal of this project is to explore factors that make listening effortful for people with hearing impairment, with special focus on the need to repair perceptual mistakes by relying on context.
Role: PI

R03 DC 014309 01/11/2016 – 12/31/2018
Measuring listening effort and spectral resolution in cochlear implant patients
The goal of this study is to evaluate the impact of spectral resolution (i.e. sound quality) with regard to its effects on listening effort and also the perception of fine-grained detail in speech sounds.
Role: PI

Completed Research Support

5R01DC002932-12 Jan R. Edwards (PI) 2012-2013
Goals: Longitudinal study of vocabulary growth and phonological development
My role: Postdoctoral researcher

5R01DC003083-15 Ruth Y. Litovsky (PI) 2012-2015
Goals: Exploring binaural sensitivity and spatial hearing in people with bilateral cochlear implants
My role: Postdoctoral researcher

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Jeffry A. Simpson

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Professor and Chair

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Illinois, Champaign-Urbana, IL	B.A.	05/1981	Political Science & Psychology
University of Minnesota, Minneapolis, MN	Ph.D.	07/1986	Psychology

A. Personal Statement

In recent years, our lab has been assessing how implicit (unconscious) attitudes affect different kinds of social behavior. Thus, as a consult on this R21 application, I bring skills and knowledge sets that will facilitate this team effort. First, I have conducted several prior research projects that have measured implicit attitudes to determine how they predict various outcomes. As a result, I have a great deal of experience with research different implicit assessment methods and techniques, including both data reduction and data analytic techniques needed to contribute to this part of the proposed research. Second, I am the PI on a current NSF grant focusing on how implicit relative to explicit attitudes toward children are related to different measures of parental investment. Many of the central aims this R21, therefore, are well aligned with my expertise on measuring implicit attitudes, and I know how to test between competing models. This will help the current research team tie the findings more clearly and tightly with other related work in this area.

B. Positions and Honors

Positions

1986–1987 Visiting Assistant Professor, Department of Psychology, Texas A&M University, College Station, TX
1987–1992 Assistant Professor, Department of Psychology, Texas A&M University, College Station, TX
1992–1997 Associate Professor, Department of Psychology, Texas A&M University, College Station, TX
1997–2004 Professor, Department of Psychology, Texas A&M University, College Station, TX 2004–present Professor, Department of Psychology, University of Minnesota, Minneapolis, MN
2006-present Director, Doctoral Minor in Interpersonal Relationships (IREL), University of Minnesota
2008-present Adjunct Professor, Institute of Child Development, University of Minnesota
2012-present Adjunct Professor, Department of Communication, University of Minnesota
2018-present Chair, Department of Psychology, University of Minnesota

Other Experience and Professional Memberships

1996-1998 Social Psychology Panel (member), *National Science Foundation*
1998-2001 Editor, *Personal Relationships*, 1998-2001
2002-2004 Social Psychology, Personality, and Interpersonal Processes Panel (ad hoc), *National Institutes of Health*
2002-2008 Associate Editor, *Journal of Personality and Social Psychology: Interpersonal Relations and Group Processes*

2004-2006	Social Psychology, Personality, and Interpersonal Processes Panel (member), *National Institutes of Health*
2006-2008	Social Psychology, Personality, and Interpersonal Processes Panel (chair), *National Institutes of Health*
2008-2014	Editor, *Journal of Personality and Social Psychology: Interpersonal Relations and Group Processes*
2014-2018	Special Emphasis Panel (member), *National Institute of Aging*
Fellow	*American Psychological Association*
Fellow	*Association for Psychological Science*
Fellow	*Society for Personality and Social Psychology*
Fellow	*Society of Experimental Social Psychology*
President	*International Association for Relationship Research* (2014-2016)

Honors

1981	Phi Beta Kappa, University of Illinois
1984-1985	Eva O. Miller Fellowship, University of Minnesota
1985-1986	Doctoral Dissertation Fellowship, University of Minnesota
1990-1991	University Honors Program Teacher/Scholar Award, Texas A&M University
1992	Young Investigator Award, *Society of Experimental Social Psychology*, Relationships
Group 1992	Sigma Xi, Texas A&M University
1995	Erskine Fellowship, University of Canterbury, New Zealand
1995	Distinguished Teaching Award, Association of Former Students, Texas A&M University
1998	New Contribution Award (best scientific article published in 1995-1996), *International Society for the Study of Personal Relationships*
1999	Distinguished Research Award, College of Liberal Arts, Texas A&M University
2001-2004	University Faculty Fellow, Texas A&M University
2003	University Distinguished Research Award, Texas A&M University
2004	Berscheid-Hatfield Award for Distinguished Mid-Career Achievement, *International Association for Relationship Research*
2009	Deiner Award for Distinguished Mid-Career Achievement, *Society of Personality and Social Psychology*
2011-2014	Scholar of the College, College of Liberal Arts, University of Minnesota
2012	Seelye Charitable Trust Fellowship, University of Auckland, New Zealand
2015	Honorary Fellow, *The Royal Society of New Zealand*
2017	Distinguished University Teaching Professor Award, University of Minnesota
2018	Distinguished Mentoring Award, International Association for Relationship Research

C. Contributions to Science

The Impact of Early Life Stress/Threat on Physical, Mental Health, and Personal Outcomes. Recent theory and research suggests that exposure to stressful (threatening) events early in life may lead to biological and mental "calibrations" that shunt individuals down different developmental trajectories over the life course. For example, individuals who are exposed to unpredictable forms of stress early in life learn that they must take risks and be opportunistic in order to obtain the outcomes they want or need, given the unstable, less predictable environments they are likely to inhabit as adults. Conversely, individuals exposed to less stressful, more stable early environments learn that making long-term investments in themselves, in others, and in high- quality, long-term relationships typically result in obtaining the best outcomes. During the past decade, my colleagues and I have tested various models grounded in some of these key life history ideas by studying how different types and amounts of stress experienced at different points of development prospectively predict an array of important life outcomes, ranging from physical and mental health, to risky sexual behavior, and to risky financial decision-making. Five recent sample publications are listed below:

- **Simpson, J. A.**, Griskevicius, V., Kuo, S. I., Sung, S., & Collins, W. A. (2012). Evolution, stress, and sensitive periods: The influence of unpredictability in early versus late childhood on sex and risky behavior. *Developmental Psychology, 48*, 674-686. doi: 10.1037/a0027293
- Puig, J., Englund, M. M., **Simpson, J. A.**, & Collins, W. A. (2013). Predicting adult physical illness from infant attachment: A prospective longitudinal study. *Health Psychology*, *32*, 409-417. doi: 10.1037/a0028889
- Griskevicius, V., Ackerman, J. M., Cantú, S. M., Delton, A. W., Robertson, T. E., **Simpson, J. A.**, Thompson, M. E., & Tybur, J. M. (2013). When the economy falters do people spend or save? Responses to resource scarcity depend on childhood environments. *Psychological Science, 24,* 197-205. doi: 10.1177/0956797612451471
- Farrell, A. K., **Simpson, J. A.,** Englund, M. M., Carlson, E. A., & Sung, S. (2017). The impact of stress at different life stages on physical health and the buffering effects of maternal sensitivity. *Health Psychology, 36*, 35-44. doi: 10.1037/hea0000424
- Johnson, W., Huelsnitz, C., Carlson, E. A., Roisman, G. I., Englund, M. M., Miller, G. E., & **Simpson, J. A.** (2017). Childhood abuse and neglect and physical health at midlife: Prospective, longitudinal evidence. *Development and Psychopathology, 29*, 1935-1946. doi: 10.1017/S095457941700150X

The Developmental Antecedents of Adult Romantic Relationship Outcomes. For years, many psychologists assumed that the key predictors of the quality and satisfaction of adult romantic relationships existed within the interpersonal context of the relationship (e.g., each partner's personality, how well each partner behaved toward the other, how much each partner cared about the other). Even though these contemporaneous variables are important predictors of many basic romantic relationship outcomes, they do not tell the entire story. Working with my colleagues on the MLSRA project, we have identified how early-life attachment status, the quality of early care received from mothers, and other forms of stress and support provision systematically predict how longitudinally studied adults think, feel, and behave when they are observed having conflict discussions with their romantic partners and when they are observed trying to recover emotionally from these discussions. Five sample publications from this line of research are listed below:

- **Simpson, J. A.**, Collins, W. A., Tran, S., & Haydon, K. C. (2007). Attachment and the experience and expression of emotions in adult romantic relationships: A developmental perspective. *Journal of Personality and Social Psychology, 92*, 355-367. doi: 10.1037/0022-3514.92.2.355
- Salvatore, J. E., Kuo, S. I., Steele, R. D., **Simpson, J. A.**, & Collins, W. A. (2011). Recovering from conflict in romantic relationships: A developmental perspective. *Psychological Science, 22,*376-383. doi: 10.1177/0956797610397055
- Oriña, M. M., Collins, W. A., **Simpson, J. A.**, Salvatore, J. E., Haydon, K. C., & Kim, J. S. (2011). Developmental and dyadic perspectives on commitment in adult romantic relationships. *Psychological Science, 22,* 908-915. doi: 10.1177/0956797611410573
- Raby, K. L., Roisman, G. I., **Simpson, J. A.**, Collins, W. A., & Steele, R. D. (2015). Maternal insensitivity in childhood predicts greater electrodermal reactivity during conflict discussions with adult romantic partners. *Psychological Science, 26,* 348-353. doi: 10.1177/0956797614563340
- Labella, M. H., Johnson, W. F., Martin, J., Ruiz, S. K., Shankman, J. L., Egeland, B., Englund, M. M., Collins, W. A., & Roisman, G. I., & **Simpson, J. A.** (2018). Multiple dimensions of childhood abuse and neglect prospectively predict poorer romantic functioning in adulthood. *Personality and Social Psychology Bulletin, 44*, 238-251. doi: 10.1177/0146167217736049

Attachment Orientations and the Quality/Functioning of Romantic Relationships. For the past 30 years, I (along with several collaborators, especially Steven Rholes) have investigated how attachment working models (which are assessed with attachment measures) affect the quality and functioning of romantic relationships, both immediately (while partners are engaged in stressful lab tasks) and across time. Most of this research, which is reviewed and synthesized in Simpson and Rholes (2012), has examined how acute stressors such as fear, the stress of trying to resolve major relationship conflicts, or the challenge of supporting a highly distressed partner influence the way in which secure, anxious, and avoidant people think, feel, and especially behave in these challenging situations. We have also studied how the *partners* of insecurely attached people can—and often do—buffer their partners from displaying the relationship-damaging thoughts, feelings, and behaviors that insecurely attached people often enact when in these stressful situations. Five recent sample publications are listed below:

- **Simpson, J. A.,** & Rholes, W. S. (2012). Adult attachment orientations, stress, and romantic relationships. In P. G. Devine, A. Plant, J. Olson, & M. Zanna (Eds.), *Advances in Experimental Social Psychology, 45,* 279-328. doi: 10.1016/B978-0-12-394286-9.00006-8
- Haydon, K. C., Collins, W. A., Salvatore, J. E., **Simpson, J. A.,** & Roisman, G. I. (2012). Shared and distinctive origins and effects of adult attachment representations: The developmental organization of romantic functioning. *Child Development, 83,* 1689-1702. doi: 10.1111/j.1467-8624.2012.01801.x
- **Simpson, J. A**., & Overall, N. C. (2014). Partner buffering of attachment insecurity. *Current Directions in Psychological Science, 23,* 54-59. doi: 10.1177/0963721413510933
- Overall, N. C., Fletcher, G. J. O., **Simpson, J. A.,** & Fillo, J. (2015). Attachment insecurity, biased perceptions of romantic partners' negative emotions, and hostile relationship behavior. *Journal of Personality and Social Psychology, 108,* 730-749. doi: 10.1037/a0038987
- Girme, Y. U., Agnew, C. R., Harvey, S. M., VanderDrift, L. W., Rholes, W. S., & **Simpson, J. A.** (2018). The ebbs and flows of attachment: Within-person fluctuations in attachment undermine secure individuals' relationship wellbeing across time. *Journal of Personality and Social Psychology, 114,* 397- 421. doi: 10.1037/pspi0000115

The Transition to Parenthood, Chronic Stress, and Adaptation. The transition to parenthood is one of the most intensely and chronically stressful life events that the majority of people in our society encounter at some point during their lives. In general, most new parents experience sharp downturns in relationship quality and upturns in physical and/or mental health problems during the first 1-3 years of the transition period. Not everyone, however, experiences relationship declines or more personal problems; some partners remain steady, and a few actually report improvements in well-being. Who are the individuals who experience declines in marital satisfaction and/or increases in depression, and which individuals tend to fare better? Our longstanding research on the transition to parenthood, much of which has adopted an attachment perspective, has shed clarifying light on these important questions. Five sample publications from this program of research are listed below:

- Rholes, W. S., **Simpson, J. A.**, Campbell, L., & Grich, J. (2001). Adult attachment and the transition to parenthood. *Journal of Personality and Social Psychology, 81,* 421-435. doi: 10.1037/0022-3514.81.3.421
- **Simpson, J. A.**, Rholes, W. S., Campbell, L., Tran, S., & Wilson, C. L. (2003). Adult attachment, the transition to parenthood, and depressive symptoms. *Journal of Personality and Social Psychology, 84,* 1172-1187. doi: 10.1037/0022-3514.84.6.1172
- Rholes, W. S., **Simpson, J. A.**, Kohn, J. L., Wilson, C. L. Martin, A. M., Tran, S., & Kashy, D. A. (2011). Attachment orientations and depression: A longitudinal study of new parents. *Journal of Personality and Social Psychology, 100,* 567-586. doi: 10.1037/a0022802
- Fillo, J., **Simpson, J. A.**, Rholes, W. S., & Kohn, J. L. (2015). Dads doing diapers: Individual and relational outcomes associated with the division of childcare across the transition to parenthood. *Journal of Personality and Social Psychology, 108,* 298-316. doi: 10.1037/a0038572
- **Simpson J. A.** & Rholes, W. S. (in press). Adult attachment orientations and well-being during the transition to parenthood. *Current Opinion in Psychology, 25,* 47-52. doi: 10.1016/j.copsyc.2018.02.019

Human Mating from an Evolutionary/Life History Perspective. In recent years, growing attention has focused on the evolutionary pressures that our ancestors most likely faced during evolutionary history and how these pressures may have affected the way in which we think, feel, and behave in different types of situations and life domains. One domain that has been of key interest is mating patterns in humans. In 2000, Steve Gangestad and I develop what has become one of the 3 or 4 major theoretical models of human mating in the biological, social, and life sciences—strategic pluralism theory. This model, which has launched hundreds of published studies, suggests the human females evolved to make trade-offs between a prospective male partner's willingness and ability to invest (parental investment) and his evidence of having "good genes" (associated with better health and higher reproductive success). Women are conjectured to make these trade-offs while weighing specific features of their current environments (e.g., the prevalence of pathogens, the availability of caregiving help from kin, the environmental need for biparental care). Strategic pluralism theory also helped launch research on how the female ovulatory cycle intersects with short-term and long-term mating decisions in women. Five sample publications from this line of research are listed below:

- Gangestad, S. W., & **Simpson, J. A.** (2000). The evolution of human mating: Trade-offs and strategic pluralism. *Behavioral and Brain Sciences, 23*, 573-587. doi: 10.1017/ S0140525X 0000 337X
- Gangestad, S. W., Garver-Apgar, C. E., **Simpson, J. A.**, & Cousins, A. J. (2007). Changes in women's mate preferences across the ovulatory cycle. *Journal of Personality and Social Psychology, 92*, 151-163. doi: 10.1037/0022-3514.92.1.151
- Cantú, S. M., **Simpson, J. A.**, Griskevicius, V., Weisberg, Y. J., Durante, K. M., & Beal, D. (2014). Fertile and selectively flirty: Women's behavior toward men changes across the ovulatory cycle. *Psychological Science, 25*, 431-438. doi: 10.1177/0956797613508413
- Fletcher, G. J. O., **Simpson, J. A.**, Campbell, L., & Overall, N. C. (2015). Pair-bonding, romantic love, and evolution: The curious case of Homo sapiens. *Perspectives on Psychological Science, 10*, 20-36. doi: 10.1177/1745691614561683
- Szepsenwol, O., & **Simpson J. A.** (in press). Attachment within life history theory: An evolutionary perspective of individual differences in attachment. *Current Opinion in Psychology, 25*, 65-70. doi: 10.1016/j.copsyc.2018.03.005

D. Research Support

Ongoing

Australian Research Council (Karantzas) 01/01/16-12/31/18

Caring for older parents: Determining the role of attachment security (ARC)

This research is investigating: (1) how attachment bonds between adult children and older parents influence the parental care provided by children in later life, caregiver burden, and parents' satisfaction with care; and (2) the effects of enhancing caregivers' attachment security on caregiving interactions and caregiver burden. This project will provide insights into strategies to strengthen family bonds and services required to support caregivers and care recipients and enhance the sustainability of aged care in the community.

Role: International co-Investigator

National Science Foundation (Simpson) 09/1/17-08/30/20

Developmental and interpersonal antecedents of parenting orientations and behavior: A life history perspective (NSF)

This research is: (1) examining whether certain types/amounts of perceived early-life stress are associated with parenting orientations and behavior in a family context, (2) investigating whether certain aspects of the current romantic relationship buffer exposure to early-life stress, (3) identifying whether different types/amounts of perceived early-life stress are associated with fathers' and mothers' implicit (vs. explicit) parenting attitudes, and (4) determining whether implicit parenting attitudes mediate the link between early-life stress and explicit parenting orientations.

Completed

R01 AG039453 (Simpson) 09/30/11-06/30/18

Early Life Stress, Developmental Processes, and Adult Health (NIA)

This research examined the mechanisms responsible for associations between psychosocial stress earlier in life and health outcomes as individuals age. More specifically, using the Minnesota Longitudinal Study of Risk and Adaptation, this research tested whether, when, and how exposure to different types and amounts of stress early in life statistically interacted with life stress in adulthood to predict negative health outcomes, including standard biomarkers of health and aging.

Role: Principal Investigator

1057482 (Simpson) 06/01/11-05/30/15

Interaction of current and childhood environment on risky decision-making: An experimental and longitudinal life-history theory approach (*NSF)*

This research investigated the way in which an individual's *early childhood environment* works together with (statistically interacts with) his or her *current environment* in adulthood to influence *risk-taking* behavior in different life domains. In several laboratory experiments and analyses with the MLSRA data, we found that people who were exposed to more unpredictable stress early in life—especially during the first 5 years—were more likely to take different kinds of risk (e.g., financial, sexual, interpersonal), but only when they were also exposed to current (immediate) threat/stress. This work reveals how early unpredictable stress combines with current environmental stress to lead certain people toward greater risk-taking in adulthood

Role: Principal Investigator

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contr butors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Oxenham, Andrew, J.

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Distinguished McKnight University Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Surrey, UK	B.Mus.	06/1992	Music and Sound Recording
University of Cambridge, UK	Ph.D.	09/1995	Experimental Psychology
Institute for Perception Research (IPO), Eindhoven, The Netherlands	Postdoc	09/1997	Psychoacoustics

A. Personal Statement

I have a strong track record in studying auditory and speech perception and the effects of hearing loss and cochlear implantation on speech perception abilities. I am excited to be collaborating with the PI, Dr. Munson, on this proposal, as I believe our experience complement each other's in ways that will lead to synergy in the resulting scientific approaches. In particular, I am keen to be involved in studying the interactions between the talker and perceiver in measures of speech intelligibility. This important component has not received sufficient attention, and could play a particularly important role in the speech understanding of people with hearing difficulties. The references below are examples of my work in speech perception in populations with hearing loss and cochlear implants.

References:

Feng, L., Oxenham, A. J. (2018). "Effects of spectral resolution on speech context effects in cochlear-implant users," *Journal of the Acoustical Society of America* 143, EL468-473.

Oxenham, A. J., Kreft, H. (2014). "Speech perception in tones and noise via cochlear implants reveals influence of spectral resolution on temporal processing," *Trends in Hearing* 18, 1-14.

Ruggles, D. R., Freyman, R. L., Oxenham, A. J. (2014). "Influence of musical training on understanding voiced and whispered speech in noise," *PLOS One* 9, e86980, 1-8.

Gregan, M. J., Nelson, P. B., Oxenham, A. J. (2013). "Behavioral measures of cochlear compression and temporal resolution as predictors of speech masking release in hearing-impaired listeners," *Journal of the Acoustical Society of America* 134, 2895-2912.

B. Positions and Honors

Positions and Employment

1995-1997 Wellcome Trust International Prize Research Fellow at the Institute for Perception Research (IPO), Eindhoven, The Netherlands.

1997-1999 Research Scientist, Northeastern University, Department of Speech-Language Pathology and Audiology.

1999-2002 Research Scientist, Research Laboratory of Electronics, MIT.

2003-2006 Principal Research Scientist, Research Laboratory of Electronics, MIT.

2006-2007 Assistant Professor, Department of Psychology, University of Minnesota
2007-2010 Associate Professor, Department of Psychology, University of Minnesota
2008-2010 Adjunct Associate Professor, Department of Otolaryngology, University of Minnesota
2010-present Professor, Department of Psychology, University of Minnesota
2010-present Professor, Department of Otolaryngology, University of Minnesota
2013-present Distinguished McKnight University Professor, University of Minnesota

Other Experience and Professional Memberships

1992- Member, Acoustical Society of America, Association for Research in Otolaryngology, American Auditory Society
2001-2004 Psychological and Physiological Acoustics Technical Committee, Acoustical Society of America
2004 - Ad hoc reviewer for NIH panels, including R01s, R03s, Training and Fellowship grants.
2004-2007 Associate Editor, Journal of the Acoustical Society of America
2006-2009 Associate Editor, Journal of the Association for Research in Otolaryngology
2008-2011 Chair, Technical Committee for Psychological and Physiological Acoustics, Acoustical Society of America
2010-2014 Standing member of the NIH CDRC review panel
2013-2014 Chair, NIH CDRC review panel
2013-2014 Section Editor, Ear and Hearing
2015-2018 Executive Council Member, Acoustical Society of America
2014-present Editor in Chief, Trends in Hearing

Honors

2001 R. Bruce Lindsay Award, Acoustical Society of America
2003 Ear and Hearing Editor's Award for Best Paper of 2003 (Oxenham and Bacon, 2003).
2003 Fellow of the Acoustical Society of America
2005 McMahon Mentoring Award, Harvard–MIT Division of Health Sciences and Technology
2006 Kavli Fellow, National Academy of Sciences (Invitee to Frontiers of Science Symposium)
2009 Troland Award, National Academy of Sciences
2013 Distinguished McKnight University Professor, University of Minnesota
2014 Elected to the Collegium Oto-Rhino-Laryngologicum Amicae Sacrum (CORLAS). One of six non-clinician members from the US.

C. Contributions to Science

1) Behavioral measures and consequences of cochlear compression

This work emanated from my PhD dissertation with Prof. Brian C. J. Moore, where I studied the additivity of non-simultaneous masking in normal-hearing and hearing-impaired listeners. I discovered that hearing-impaired listeners tended to show less masking summation than normal-hearing listeners, and that this reduced additivity could be described in terms of reduced dynamic range compression at the front-end of an auditory model. The finding of reduced compression came at a time when the highly compressive nature of the basilar-membrane input-output function was being generally accepted, after many years of controversy in the field of auditory physiology. My follow-on work was to link cochlear compression to the compression in the model, and (together with Chris Plack) to derive a novel psychoacoustic measure of compression that was found to be in good agreement with invasive measures in other mammals. The work was used to explain several aspects of the perceptual consequences of hearing loss in terms of loss of cochlear compression, including aspects of temporal processing and speech perception, and it led to a large number of studies that continue to explore behavioral measures and consequences of cochlear nonlinearity in normal and impaired hearing.

References:

Oxenham, A. J., and Plack, C. J. (1997). "A behavioral measure of basilar-membrane nonlinearity in listeners with normal and impaired hearing," *Journal of the Acoustical Society of America* 101, 3666-3675.

Moore, B. C. J., and Oxenham, A. J. (1998). "Perceptual consequences of compression in the peripheral auditory system," *Psychological Review* 105, 108-124

Oxenham, A. J., and Bacon, S. P. (2003). "Cochlear compression: Perceptual measures and implications for normal and impaired hearing," *Ear and Hearing* 24, 352-366.

Gregan, M. J., Nelson, P. B., Oxenham, A. J. (2013). “Behavioral measures of cochlear compression and temporal resolution as predictors of speech masking release in hearing-impaired listeners,” *Journal of the Acoustical Society of America* 134, 2895-2912. PMCID: PMC3799689.

2) Behavioral and otoacoustic emission measures of human cochlear filtering

In collaboration with Chris Shera and John Guinan, I worked on a project to compare human cochlear tuning with that in smaller mammals (cat, guinea-pig, chinchilla) that are typically used for auditory research. We combined stimulus-frequency otoacoustic emission (SFOAE) measurements with a new variant of the behavioral notched-noise technique to estimate human tuning and compared it with SFOAE measurements and auditory-nerve tuning curves in the other mammals. We found that the pattern of tuning (increasing sharpness with increasing center frequency) was very similar across the species, but that human tuning appeared to be sharper than that in the smaller mammals, by a factor of about 2. Although the finding remains controversial, it has received recent support from other groups, who have reported intermediate tuning in old-world monkeys (Joris et al., 2011, PNAS). The work has important implications for any conclusions about human auditory perception and processing, based on animal physiology and auditory models. In collaboration with Torsten Dau, we also devised methods to estimate the phase curvature of the auditory filters across the frequency spectrum. In combination the data from these collected studies provides the necessary data to derive a comprehensive description of human auditory filtering.

References:

Oxenham, A. J., and Dau, T. (2001). “Towards a measure of auditory-filter phase response,” *Journal of the Acoustical Society of America* 110, 3169-3178

Shera, C. A., Guinan, J. J., and Oxenham, A. J. (2002). “Revised estimates of human cochlear tuning from otoacoustic and behavioral measurements,” *Proceedings of the National Academy of Sciences USA* 99, 3318-3323.

Oxenham, A. J., and Simonson, A. M. (2006). “Level dependence of auditory filters in nonsimultaneous masking as a function of frequency,” *Journal of the Acoustical Society of America* 119, 444-453.

Shera, C. A., Guinan, J. J., and Oxenham, A. J. (2010). “Otoacoustic estimation of cochlear tuning: Validation in the chinchilla,” *Journal of the Association for Research in Otolaryngology* 11, 343-365. PMCID: PMC2914235.

3) Pitch perception and processing in normal and impaired hearing

Our work on pitch perception has focused on questions regarding the basic mechanisms of F0 coding in the auditory periphery and its role in speech understanding in complex environments. Our early work confirmed that resolved harmonics were necessary for accurate pitch perception, but found that artificially resolving higher-order harmonics did not lead to better pitch perception, suggesting a role of templates formed only of normally resolved harmonics. We have also examined the role of different temporal cues for pitch and speech perception. Our work on ‘auditory chimeras’, which attempted to dissociate the role of temporal fine structure from temporal envelope has been highly cited (over 500 according to Google Scholar) and has inspired many follow-up studies. Using ‘transposed stimuli’ that present low-frequency temporal information to high-frequency cochlear locations, we demonstrated that timing information was not sufficient to induce complex pitch perception. Later, using very high-frequency harmonics (> 6 kHz), we showed that phase-locked information was also not necessary to induce complex pitch perception. Overall, the results have moved forward the field of pitch perception research and have overturned some ‘textbook facts’, such as the absence of pitch when all components were higher than 5 or 6 kHz, which in turn have changed how we view the basic mechanisms of pitch.

References:

Smith, Z. M., Delgutte, B., and Oxenham, A. J. (2002). “Chimaeric sounds reveal dichotomies in auditory perception,” *Nature* 416, 87-90

Oxenham, A. J., Bernstein, J. G. W., and Penagos, H. (2004). “Correct tonotopic representation is necessary for complex pitch perception,” *Proceedings of the National Academy of Sciences USA* 101, 1421-1425.

Oxenham, A. J., Micheyl, C., Keebler, M. V., Loper, A., Santurette, S. (2011). “Pitch perception beyond the traditional existence region of pitch,” *Proceedings of the National Academy of Sciences USA*. 108, 7629-7634. PMCID: PMC3088642.

Lau, B. K., Mehta, A. H., Oxenham, A. J. (2017). “Superoptimal Perceptual Integration Suggests a Place-Based Representation of Pitch at High Frequencies,” *Journal of Neuroscience* 37, 9013-9021. PMCID: PMC5597982.

4) Auditory streaming and perceptual organization

We provided the first demonstration that auditory stream segregation can occur in the absence of tonotopic (cochlear) differences between stimuli by inducing streaming of complex harmonic tones, comprising of only unresolved harmonics. We have also manipulated the interactions between simultaneous and sequential grouping constraints to induce an interesting illusion, whereby a component potentially belonging to two objects is allocated to neither and perceptually 'disappears'. More recently, we combined human behavioral and animal single-unit data to show how streaming depends on temporal coherence and how it is represented in A1. We have also demonstrated MEG correlates of auditory awareness, showing that early cortical responses to pure tones are robustly present, whether or not they are detected, whereas later responses (latency of ~100 ms) seem entirely absent when the tones remain undetected or unattended.

References:

Gutschalk, A., Micheyl, C., and Oxenham, A. J. (2008). "Neural correlates of auditory perceptual awareness under informational masking," *PLOS Biology* 6, 1156-1165 (e138). PMCID: PMC2422852.

Elhilali, M., Ma, L., Micheyl, C., Oxenham, A. J., and Shamma, S. (2009) "Temporal coherence in the perceptual organization and cortical representation of auditory scenes," *Neuron* 61, 317-329. PMCID: PMC2673083.

McDermott, J. H., Wrobleski, D., Oxenham, A. J. (2011). "Recovering sound sources from embedded repetition," *Proceedings of the National Academy of Sciences USA* 108, 1188-1193. PMCID: PMC3024660.

Lu, K., Xu, Y., Yin, P., Oxenham, A. J., Fritz, J., Shamma, S. A. (2017). "Temporal coherence structure rapidly shapes neuronal interactions," *Nature Communications* 7, 13900 doi:10.1038/ncomms13900. PMCID: PMC5206281

5) Effects of spectro-temporal interactions in speech perception by cochlear-implant users

Our lab has made a number of discoveries concerning auditory perception via cochlear implants, and have developed new tests for rapid assessment of thresholds and spectral tuning. One potentially important finding relates to the influence of inherent temporal-envelope fluctuations in noise on the ability to understand speech. Earlier work in normal-hearing listeners showed that speech perception was limited by the presence of the temporal envelope fluctuations inherent in noise. Our surprising results showed that this was not the case for cochlear-implant users, despite the fact that they rely on envelope information to understand speech (Oxenham and Kreft, 2014). We explained the results in terms of poorer spectral resolution leading to spectrally overlapping temporal envelopes, which in turn smoothed out the envelope fluctuations of the noise. We were able to reproduce the results from cochlear-implant users in a group of normal-hearing listeners by simulating the expected effects of spectral spread. The results also suggested new and more sensitive ways to test spectral resolution in cochlear-implant users. More recently, we have discovered that some, but not all, aspects of auditory enhancement are found in cochlear-implant users (Kreft and Oxenham, 2017), suggesting that the missing aspects could be restored via signal processing.

Wang, N., Kreft, H. A., Oxenham, A. J. (2015). "Loudness context effects in normal-hearing listeners and cochlear-implant users," *Journal of the Association for Research in Otolaryngology* 16, 535-545. PMCID: PMC4488167

Oxenham, A. J., Kreft, H. (2014). "Speech perception in tones and noise via cochlear implants reveals influence of spectral resolution on temporal processing," *Trends in Hearing* 18, 1-14. PMCID: PMC4227666.

Kreft, H. A., Nelson, D. A., Oxenham, A. J. (2013). "Modulation frequency discrimination with modulated and unmodulated interference in normal hearing and in cochlear-implant users," *Journal of the Association for Research in Otolaryngology* 14, 591-601. PMCID: PMC3705089.

Wang, N., Kreft, H., and Oxenham, A. J. (2012). "Vowel enhancement effects in cochlear-implant users," *Journal of the Acoustical Society of America* 131, EL421-426. PMID: 22713016.

Complete list of published works in MyBibliography:

My bibliography is available here (total of 155+ peer-reviewed journal articles):
http://www.ncbi.nlm.nih.gov/sites/myncbi/andrew.oxenham.1/bibliography/40507433/public/?sort=date&direction=ascending

D. Additional Information: Research Support and/or Scholastic Performance

NSF-BCS 1840818 Oxenham (PI) 09/15/2018-08/31/2020
NSF
NeuroDataRR. Collaborative Research: Testing the relationship between musical training and enhanced neural coding and perception in noise
This multi-site project seeks to replicate findings relating musical training to enhanced neural coding and auditory and speech perception in noise.
Role: Lead PI

R01 DC 012262 Oxenham (PI) 03/01/2013-02/28/2019
NIH/NIDCD
Spectro-temporal interactions in electric and acoustic processing and auditory perception
This project studies auditory and speech perception in cochlear-implant users and hearing-impaired listeners and is designed to develop new processing algorithms to aid speech perception in complex and changing acoustic environments.
Role: PI

R01 DC 005216 Oxenham (PI) 02/01/2002-01/31/2022
NIH/NIDCD
Complex pitch perception in complex environments
This study uses behavioral methods to investigate the mechanisms of pitch perception in normal and impaired hearing and their role in understanding speech in complex backgrounds.
Role: PI

R01DC015987 M. Wojtczak (PI) 04/01/2017-03/31/2022
NIH/NIDCD
Physiological measures and perceptual consequences of noise-induced auditory synaptopathy in humans
This study investigates the newly discovered phenomenon of “hidden hearing loss” in humans to develop behavioral and non-invasive physiological tests and to determine whether this is a widespread problem in our population.
Role: Co-investigator

R01DC015462 M. Wojtczak (PI) 07/01/2017-06/30/2022
NIH/NIDCD
Perceptual and functional role of medial olivocochlear efferents in humans
This study investigates the potential role of efferents in auditory and speech perception, and explores novel ways to measure efferent activation in humans.
Role: Co-investigator

Past research support

R01 DC 007657 S. Shamma (PI) 04/01/2006-05/31/2017
NIH/NIDCD
Neural Correlates of Streaming of Complex Sounds
This study combines human behavioral and animal neural studies in awake behaving ferrets to study the neural correlates of auditory scene analysis.
Role: PI of University of [redacted] subcontract

BIOGRAPHICAL SKETCH

NAME: Peggy B. Nelson

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Professor

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
St Olaf College, Northfield, MN	B.A.	05/1974	Psychology, Mathematics
Kansas State University, Manhattan, KS	M.A.	05/1982	Speech (Audiology)
University of Kansas, Lawrence, KS	Ph.D.	04/1991	Audiology

A. Personal Statement

I am very enthused and I believe well positioned to contribute to the proposed project on social variation in audiovisual speech perception, in particular as it pertains to studying older persons and people with hearing loss. We are just completing a study of self-adjusting hearing aids, and the results are promising and exciting. I have extensive experience evaluating listeners' speech understanding in background noise. I have direct experience in measuring the diversity of speech recognition abilities and other outcome measures seen in groups of listeners with similar hearing loss. I bring audiological expertise in devising appropriate speech tests for our subjects. I direct a multisensory research laboratory (Center for Applied and Translational Sensory Science, CATSS) and have extensive experience collaborating with other investigators who study vision and vision loss. We currently have initiated a study on the audiovisual perception of spatial cues. I believe we have an outstanding team and strong preliminary data to launch this important project.

I have worked in translational projects with industry partners on research and training projects. Some of our recent findings have implications for clinical practice, including the following from the past five years:

1. Nie, Y., Zhang, Y., and Nelson, P.B. (2014) Auditory stream segregation using bandpass noises: evidence from event-related potentials. Frontiers in Neuroscience. Vol. 8 August, doi: 10.3389
2. Miller, S., Zhang, Y. and Nelson, P (2015) Efficacy of multiple-talker phonetic identification training in postlingually deafened cochlear implant listeners. Journal of Speech, Language, and Hearing Research doi:10.1044/2015_JSLHR-H-15-0154
3. Svec, A., Nelson, P. and Dubno, J. (2016) "Inherent envelope fluctuations in forward maskers: Effects of masker-probe delay for listeners with normal and impaired hearing" J Acoust. Soc. Am. 139, 1195 (2016); http://dx.doi.org/10.1121/1.4944041
4. Nelson, P., Gregan, M., Perry, T., and VanTasell, D. (2018) "Self-adjusted amplification parameters produce large between-subject variability and preserved speech intelligibility in noise", Trends in Hearing. 22. 1 – 13. doi.org/10.1177/2331216518798264

B. <u>Positions and Honors:</u>

1974 - 1975: Teacher aide, interpreter, Central NC School for the Deaf
1975 - 1977: Director, Guilford County (NC) Communications Center for the Deaf
1977 - 1979: Sign interpreter, sign language instructor, Pima County (AZ) Community College
1979 - 1982: Graduate Assistant, Purdue University and Kansas State University
1982 - 1988: Instructor, Audiology, Speech Pathology/Audiology Program, Kansas State Univ.
1988 - 1992: Instructor/Clinic Director, Hearing and Speech Dept, Univ. of Kansas Medical Center

1992 - 1996: Research scientist, Gallaudet University Center for Auditory and Speech Sciences,
1996 - 1999: Assistant Professor and Director of Pediatric Audiology, Div. of Otolaryngology, UMB
1997 - 1999: Adjunct Assistant Professor, Dept. of Audiology & SLP, Gallaudet University
2000 – 2005: Assistant Professor, Dept. of Communication Disorders, University of Minnesota
2005 – 2012: Associate Professor, Department of Speech-Language-Hearing Sci., Univ. of Minnesota
2008 – 2015: Chair, Department of Speech-Language-Hearing Sciences, Univ. of Minnesota
2013 – Present: Professor, Department of Speech-Language-Hearing Sciences, Univ. of Minnesota
2015 – Present: Director, Center for Applied and Translational Sensory Science, Univ. of Minnesota

National Board Memberships:

1999 – 2002 & 2011 - present: Member, Physiological and Psychological Acoustics Technical Cmte, ASA
1999 – present: Member, Acoustical Society of America Committee on Women in Acoustics
1997 – present: Member, Acoustical Society of America (ASA) Task Force on Classroom Acoustics
2002 – 2007: Member, American Speech-Language-Hearing Assoc Research and Scientific Affairs
2002 – 2009: Member, Speech Communication Technical Committee, Acoustical Society of America
2006 – 2009: Member, executive council, Acoustical Society of America
2007 – present: Member, American Academy of Audiology Task Force on classroom acoustics
2013 – present: Vice Chair of ANSI Standards S3 Committee
2014 – present: Vice President for Scholarship and Research, Council of Academic Programs of Communication Sciences and Disorders
2018 – present: Vice President elect, Acoustical Society of America

Honors:

2002, Editor's award, American Journal of Audiology
2003, Editor's award, American Journal of Audiology
2005, Fellow of the Acoustical Society of America
2010, Fellow of the American Speech-Language-Hearing Association
2011, Editor's award, ASHA Leader

C. Contributions to Science

1. My early projects investigated factors affecting speech perception in listeners with hearing loss. These focused on speech-like psychoacoustic tasks that were closely related to speech perception tasks, in listeners with cochlear hearing loss (hearing aid users) and those with severe loss who use cochlear implants. Together with doctoral students, we have investigated the effects of increased signal level, audibility of the signal, spectral resolution, and the resulting speech abilities in quiet. Relationships revealed considerable variability in speech recognition unexplained by psychoacoustic abilities, audibility, or level. Publications include:
    a. Nelson, P., & Dwyer-Thomas, S. (1997). Gap detection as a function of stimulus loudness for listeners with and without hearing loss. *Journal of Speech, Language, and Hearing Research*, *40*, 1387-1394.
    b. DiGiovanni, J., Nelson, P., & Schlauch, R. (2005). A psychophysical evaluation of spectral enhancement. *Journal of Speech, Language, and Hearing Research*. 48 (5), 1121-1135. 16411801
    c. Munson, B., & Nelson, P. (2005). Phonetic identification in quiet and in noise by listeners with cochlear implants. *Journal of Acoustical Society of America 118,* 2607-2617.
    d. Miller, S., Zhang, Y. and Nelson, P. (2016) Neural correlates of phonetic learning in postlingually deafened cochlear implant listeners, *Ear and Hearing* 37 (3), 247-374. DOI: 10.1097/AUD.0000000000000287

2. A second area focused on the effects of room acoustics on listener performance, including listeners with hearing loss, and listening in second languages. Some work was coordinated with the Acoustical Society of America classroom acoustics coalition. Study of hearing devices and second language

learning revealed complex negative effects of background noise on learning. Studies were highly collaborative with colleagues and graduate students in multiple universities. Publications include:

a. Knecht, H., Nelson, P. Whitelaw, G., & Feth, L. (2002) Background noise levels and reverberation times in unoccupied classrooms: Predictions and measurements, *American Journal of Audiology*, 11, 65-71.
b. Miller-Hansen, D.R., Nelson, P., Widen, J. E., & Simon, S. D. (2003). Evaluating the benefit of speech recoding hearing aids in children. *American Journal of Audiology*, *12*, 106-113.
c. Nelson, P., Kohnert, K., Sabur, S., & Shaw, D. (2005). Classroom noise and children learning through a second language: Double jeopardy? *Language, Speech, and Hearing Services in Schools, 36,* 219 – 229.
d. Koerner, T., Zhang Y, Nelson P, Wang, B. and Zou, H. (2017) Neural indices of phonemic discrimination and sentence-level speech intelligibility in quiet and noise: A P3 study. Hearing Research, 350: 58-67. https://doi.org/10.1016/j.heares.2017.04.009

3. A third scientific area investigated the role and nature of masking release in speech perception performance for listeners with hearing aids and cochlear implants. These were among the first papers to identify the nearly complete lack of masking release in listeners with cochlear implants, and to investigate possible causes. Several doctoral students and I collaborated on these projects, as seen in the list below. Publications include:
    a. Nelson, P., Jin, S.-H., Carney, A.E., & Nelson, D. A. (2003). Understanding speech in modulated interference: Cochlear implant users and normal-hearing listeners. *Journal of the Acoustical Society of America*, 113**,** 961-968.
    b. Nelson, P., & Jin, S.-H. (2004). Factors affecting speech understanding in gated interference: Cochlear implant users and normal-hearing listeners. *Journal of Acoustical Society of America*, *114*, 2286-2294.
    c. Jin, S. & Nelson, P. (2006) Speech perception in gated noise: the effects of temporal resolution, *Journal of Acoustical Society of America 119*, 3097 – 3108. (2, 4, 5, 6, 7)
    d. Jin, S. and Nelson, P. (2010) Interrupted speech perception: The effects of hearing sensitivity and frequency resolution, Journal of the Acoustical Society of America. 128, 881 – 889. PMC293326 (2, 4, 5, 6, 7)

4. A fourth area focused on the role of cochlear compression for performance of hearing-impaired listeners in noise. These included measures of spectral resolution and cochlear compression and their predictive ability for understanding speech in noise for listeners who use acoustic hearing and hearing aids. This work was accomplished collaboratively with colleagues and doctoral students Anderson and Gregan. No direct relationships between measures of cochlear compression and performance in noise were seen. Considerable variability in HI listeners' performance in noise pointed us in other directions for an explanation. Publications include:
    a. Gregan, M.J., Nelson, P. B. and Oxenham, A. J, and Nelson, P. (2010) Effects of background noise level on behavioral estimates of basilar-membrane compression, Journal of the Acoustical Society of America, 127, 3018 – 3025. PMID: 21117751 (2, 4, 5, 6, 7)
    b. Anderson ES, Nelson DA, Kreft H, Nelson PB, Oxenham AJ. (2011) Comparing spatial tuning curves and spectral ripple resolution in cochlear implant users, *Journal of the Acoustical Society of America,* 130, 364-375. PMID: 21786905 (2, 4)
    c. Gregan, M., Nelson, P. and Oxenham, A. (2011) Behavioral estimates of basilar-membrane compression: Additivity of forward masking in noise-masked normal-hearing listeners, *Journal of the Acoustical Society of America 130, 2835-2844 (2, 4)*
    d. Gregan, J. Nelson, P. and Oxenham, A (2013) Behavioral measures of cochlear compression and temporal resolution as predictors of speech intelligibility and masking release in hearing-impaired listeners, JASA 134, 2895-2904.(2, 4, 6, 7)

5. A fifth scientific area is the role of amplitude modulation confusion in the problem of speech recognition in noise. This research follows up on the variability noted and further explains some

problems on listeners with hearing loss, and has implications for sensory aid use. Publications include:

a. Jin, S.H., Nie, Y., and Nelson, P. (2013) Modulation interference and masking release in cochlear implant users, *American Journal of Audiology* 135-46. doi: 10.1044/1059-0889. *(2, 4, 6)*
b. Nie, Y., Zhang, Y., and Nelson, P.B. (2014) Auditory stream segregation using bandpass noises: evidence from event-related potentials. Frontiers in Neuroscience. Vol. 8 August, doi: 10.3389
c. Svec, A., Nelson, P. and Dubno, J. (2015) Inherent fluctuations in forward maskers: Effects of temporal envelope, age, and hearing loss, JASA 137, 1336–1343. dx.doi.org/10.1121/1.4908567
d. Miller, S., Nelson, P. and Zhang, Y. (2015) Efficacy of multiple-talker phonetic identification training in postlingually deafened cochlear implant listeners. Journal of Speech, Language, and Hearing Research doi:10.1044/2015_JSLHR-H-15-0154

D. Research Support

Ongoing research support:

Principal investigator, *Improving Amplification Outcomes in Noise by Self-Directed Hearing Aid Fitting 1 R01 DC 13276,* July1, 2013 - June 30, 2018. This grant focuses on fitting and follow-up for amplification systems in noisy situations. We are currently in a no-cost extension

Investigator, National Science Foundation training grant
Graduate Training Program in Sensory Science: Optimizing the Information Available for Mind and Brain, awarded to Center for Cognitive Sciences and Center for Applied and Translational Sensory Science, August 2017

Co-investigator
Xcel Energy Public Utilities Commission, 2014 - 2019
Title: Wind turbine generated sound: Targeted research to improve measurement, analysis and annoyance thresholds based on measured human response
PI: Jeffrey Marr, St Anthony Falls Laboratories

Co-investigator
Department of Energy DE-FOA-0001554: Wind energy 00 Eagle impact minimization technologies and field testing opportunities.
Detection and perception of sound by eagles and surrogated raptors
Award notice received Nov 29, 2016

Co-Investigator
Andrew Oxenham, Principal Investigator NIH R01
Spectro-temporal interactions in cochlear implant processing and perception
Spring 2013 – 2018

Co-Investigator
Magda Wojtczak, Principal Investigator NIH R01
Physiological measures and perception
Awarded Spring 2018

Completed research support:

Principal investigator, *Masking release in hearing loss: Cochlear compression and effective audibility,* National Institute on Deafness and Other Communication Disorders 1 R01 DC008306, period 4/1/08 – 3/31/13. The current grant focuses on speech understanding by listeners with hearing loss and their performance in steady and gated noise.

For the following subcontracts, which are representative of others, I serve as the local principal investigator, testing the effectiveness of new technologies for the improvement of speech understanding in noise by listeners with hearing loss:

Subcontractor, NIDRR (PI American Medical Electronics), “Connectivity to Modern Electronics for the Hearing Disabled” Oct 2010 – August 2012

Subcontract, AME Ph I NIDRR "Enhancing Conversation Intelligibility for Hearing Aid Users in Noisy Environments." Mar 2012 – Feb 2013

Subcontractor, NIH SBIR Advanced Medical Electronics, Head mounted magnetometer hearing aid. Submitted April 2012. Funded Summer 2012.

Subcontractor, NIH SBIR Phase II (PI American Medical Electronics), submitted April 1010, “Visual aide to hearing aids” Phase II funded May 2012 - October 2013

Principal investigator, NIH NIDCD 5R01DC8306 Diversity Supplement, “Masking release in hearing loss: Cochlear compression and effective audibility,” submitted May, 2009, September 2009 – May 2011

Co-investigator, *Mechanisms of auditory dysfunction,* National Institute on Deafness and Other Communication Disorders, P01-DC00110-24A2, in collaboration with D. Nelson, Department of Otolaryngology, Multi-project grant, for period 6/1/99 – 5/31/04.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contr butors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Evelyn Davies-Venn

eRA COMMONS USER NAME (credential, e.g., agency login): [redacted]

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing,*

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
University of Minnesota	B.A	05/2002	Communication Sciences and Disorders
University of Washington	M.S.	12/2004	Audiology
University of Washington	Au.D.	08/2005	Audiology
University of Washington	Ph.D.	12/2010	Audiology
Purdue University	Post-Doc	04/2014	Audiology
University of Minnesota	Post-Doc	08/2015	Audiology

A. Personal Statement

This project will evaluate the effect of listeners' knowledge and expectations of socially meaningful variation affect speech communication by individuals with hearing loss. This is a timely project that aims to determine quantitative (i.e. signal processing) and qualitative (attitudes) that will guide our efforts on the use of emerging technology to improve access and success with hearing aids. I have been greatly interested in translational research that determine behavioral factors that influence outcomes with hearing aid amplification. My current research program measures behavioral and electrophysiological factors that govern individual variance in amplification outcomes in real-world listening environments. I am excited to be contributing my expertise in measuring hearing and hearing-aid related factors that influence social effects on speech perception for older adults with hearing loss.

B. Positions and Honors

Positions

2002-2009	Research Assistant	University of Washington
2009-2010	NIH pre-doctoral Research Fellow	University of Washington
2010-2010	Visiting pre-doctoral Research Fellow	Northwestern University
2015 -	Assistant Professor	University of Minnesota

Honors

2003	McNair Scholar Graduate Fellow
2004	Graduate Opportunity Award
2004	Eugene Beebee Scholarship
2010	American Academy of Audiology Student Award
2011	ASHA Lessons for Success: Emerging Scientist Awardee
2014	International Hearing Aid Convention (IHCON) Travel Award
2015	NIH Future Leaders
2016	NIH-National Research Mentoring Network (NRMN) P3 mentee

2018 TRIO achievers award

Other Experience and Professional Memberships

2002- Member: American Academy of Audiology, Association for Research in Otolaryngology

2002- Board member: Graduate student advisory council, Diversity Recruitment Advisory Board, University of Washington. ARO Diversity and Minority Affairs Committee.

2010 - Ad-hoc Reviewer: Journal of the Acoustical Society of America, Journal of the American Academy of Audiology, Journal of Communication Sciences and Disorders, Ear and Hearing, Journal of Speech, Language, Hearing Research, IEEE signal processing.

2015- Faculty Fellow, Center for Translational and Sensory Sciences

C. Contributions to Science

My main contribution to science can be summarized as translational research designed to alleviate the speech perception difficulties experienced by listeners with hearing loss. My research focuses on the interaction between sensory aids and fundamental aspects of auditory processing. I seek to determine factors that could be personalized to optimize amplification outcomes for individuals with hearing loss.

For human psychophysics, my main contributions relate to determining the role of audibility, spectral resolution, and temporal distortion on amplification outcomes with non-linear hearing aids and devising clinical recommendations based on our research findings.

1. Dirks, C., Shahin, A., Kwan, T., and Davies-Venn, E. (2018). Effect of musical training on EEG measures of spectro-temporal processing. The Journal of the Acoustical Society of America 143 (3), 1962-1963.

2. Davies-Venn, E., Oeding, K., and Haug, A. (2018). The effects of carrier bandwidth and intensity on spectral ripple perception in listeners with hearing loss. The Journal of the Acoustical Society of America 143 (3), 1748-1748.

3. Nie, Y., **Davies-Venn, E**., Svec, A., & Nelson, P. Detection of Frequency-Glides in Gate and Steady Noise by Listeners with Normal Hearing and Sensorineural Hearing Loss. In revision for Ear and Hearing.

4. Nelson, P., and Souza, P. (2015)**.** Comparing auditory filter bandwidths, spectral ripple detection, spectral ripple discrimination and speech recognition: normal and impaired hearing. Journal of the Acoustical Society of America, 138: 492–503.

5. **Davies-Venn, E.,** and Souza, P. (2014). The role of audibility, spectral resolution, and cognition in explaining variance in susceptibility to temporal envelope distortion for listeners with mild to moderate and moderate-to-severe hearing loss. Journal of the American Academy of Audiology, 25-29.

For *speech perception assessment*, my main contribution relates to developing speech stimuli for laboratory testing and determining how non-linear amplification can be used to improve speech understanding for individuals with hearing loss.

1. Hossain, E., Davies-Venn, E., and Zilany, M (*in-press*). A Nonintrusive Predictor of Speech Intelligibility Using a First-order Spectral Moment of the Bispectrum of the Spectrogram. Computer, Speech and Language.

2. Alam, S., Zilany, M., and **Davies-Venn, E**. (2017). Effects of speech-shaped noise on consonant confusions in Malay. *IEEE Region 10 Humanitarian Technology Conference (R10-HTC:)22-25*.

3. Gibson PL, Hedin DS, **Davies-Venn E**, Nelson P, Kramer K. (2012). Multi-microphone adaptive array augmented with visual cueing. Engineering in Medicine and Biology Society (EMBC), IEEE:1000-1003.

4. **Davies-Venn, E.**, Souza P., Brennan, M., and Stecker, G. (2009). Effects of audibility and multichannel wide dynamic range compression on consonant recognition for listeners with severe hearing loss. Ear and Hearing. 30:494-504.

5. **Davies-Venn, E.,** Souza, P., and Fabry, D. (2007). Speech and Music Quality Ratings for Linear and Non-linear Hearing Aid Circuitry. Journal of the American Academy of Audiology, 1 690-70.

Complete List of Published Work in MyBibliography: here and here

D. Additional Information: Research Support and/or Scholastic Performance

On-going

Hearing Health Foundation Davies-Venn (PI) 2018-2019
Neural correlates of variance in amplification outcomes. For this project, we measure spectral processing to evaluate how lateral inhibition is enhanced or reduced at respective regions along the auditory pathway in listeners with normal auditory function. We aim to discover mechanisms that could be exploited to enhance the functional benefit of lateral inhibition in hearing aid amplification.

Brain Imaging Davies-Venn (PI) 2017-2018
Neural correlates of amplification outcomes for speech in loud and noisy environments. For this project, we measure concurrent subcortical and cortical processing of non-speech stimuli to evaluate how lateral inhibition is enhanced or reduced at respective regions along the auditory pathway in listeners with normal auditory function. We aim to discover mechanisms that could be exploited to enhance the functional benefit of lateral inhibition in individuals with enhances versus reduced inhibition.

Grant-in-aid Davies-Venn (PI) 2016-2018
Improving auditory performance variability in real-world environments
For this project, we measure concurrent speech and noise features during a real-time dialogue in a clinical population of hearing aid users. We aim to discover high-intensity mechanisms that could be enhanced in hearing aid signal processing to improve amplified speech perception in noise.

Completed Research Support
F31DC010127-02 Davies-Venn (PI) 2009 – 2010
Using spectral resolution to explain performance variability with severe loss.
This translational research study examined mechanisms that explain the listening difficulties and amplification outcomes for listeners with severe hearing loss.

BIOGRAPHICAL SKETCH

NAME: Molly E. Babel

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Associate Professor

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of Minnesota, Twin Cities, Minneapolis, MN	B.A.	2004	Linguistics, Anthropology, Spanish Studies
University of California, Berkeley, CA	M.A.	2006	Linguistics
University of California, Berkeley, CA	Ph.D.	2009	Linguistics

A. Personal Statement

I have been a faculty member at the University of British Columbia for 9 years. In that time span, I have developed an interdisciplinary research program, which intertwines methods and theories from linguistics, speech science, experimental psychology, and social psychology. With this arsenal, I explore fundamental issues related to the role of experience in language knowledge, how social knowledge is manifested phonetically, and the mental representation of linguistic knowledge. In my research, experience and social cognition encompass attributes as basic as native language to more complex issues like how social expectations play out in both speech production and speech perception. Broadly, my research agenda has a primary focus on issues of phonetic theory and the processing and representation of phonetic variation. More specifically, my research examines perception and variation in the speech signal with particular attention on the relationship between speech perception and production and how social cognition moderates speech processing. I maintain multiple lines of research which investigate several aspects of this topic.

B. Positions and Honors

Positions

Department of Linguistics, University of British Columbia, Vancouver, BC Canada.
Assistant Professor, 7/1/2009-6/30/2015.
Associate Professor with Tenure, 7/1/2015-current

Honours

1. Member of the Royal Society of Canada's College of New Scholars, Artists and Scientists (2016)
2. Visiting Professor, Department of Speech, Language, and Hearing Sciences, University of Minnesota – Twin Cities. September 1, 2015 – May 31, 2016.

Other Experience and Professional Memberships

Member of: Acoustical Society of America, Linguistic Society of America, Association of Laboratory Phonology
2012-2015 Guest Associate Editor for Frontiers in Psychology – Cognitive Science, March 2012-2015.
2018-present Member of the Executive Committee for the Association of Laboratory Phonology

C. Contribution to Science

1. Spontaneous Phonetic Accommodation

Spontaneous phonetic imitation or accommodation is the process by which a speaker unintentionally adopts acoustic characteristics of the speech patterns of a voice they are exposed to. My research in this area has had a large impact on the field. I initiated work in this area at a pivotal time, at the onset of a burst in work the area. In addition to providing novel empirical insights, my work provides a unique perspective on this work by integrating phonetic, sociolinguistic, and psycholinguistic perspectives. Babel (2012) reports on the selectivity of the phonetic accommodation process. I have extended my research on accommodation across dialects in Babel (2010) and Babel, McAuliffe, & Haber (2013), which demonstrated how structure of a language's vowel system and listener attitude affected the degree to which speech perception and production processes interact. We have continued to explore the mechanisms of phonetic accommodation through the role of surprisal in spontaneous imitation by testing the role of voice novelty (Babel, McGuire, Walters, & Nichols, 2014) and by through manipulations of cognitive load (Abel & Babel, 2016).

Abel, J., & Babel, M. (2016). Cognitive Load Reduces Perceived Linguistic Convergence Between Dyads. *Language and Speech*, 0023830916665652.

Babel, M., McGuire, G., Walters, S., & Nichols, A. (2014). Novelty and social preference in phonetic accommodation. *Journal of Laboratory Phonology*, 5, 1, 123-150.

Babel, M., McAuliffe, M. & Haber, G. (2013). Can mergers-in-progress be unmerged in speech accommodation? *Frontiers in Psychology*, 4, 653, 1-14.

Babel, M. (2012). Evidence for phonetic and social selectivity in spontaneous phonetic imitation. *Journal of Phonetics* 40, 177-189.

Babel, M., & Bulatov, D. (2012). The role of fundamental frequency in phonetic accommodation. *Language and Speech*, 55(2), 231-248.

Babel, M. (2010). Dialect convergence and divergence in New Zealand English. *Language in Society*, 4(3), 437-456.

2. Perception of Unfamiliar, Atypical, and Stereotyped Speech

How perceptual processes remain flexible (allowing us to understand a wide range of speakers and accents) yet stable (not showing dramatic changes with exposure to each unique voice) is a question that has dogged the discipline for years. In this line of work, I examine how listeners attend and adapt to unfamiliar accents or pronunciation patterns or speakers who have unanticipated pronunciation patterns. Using a range of behavioural paradigms that range from transcription tasks to categorization paradigms, we show that the nature and position of the phonetic variation affects how listeners attend to the incoming speech stream. These results have implications for theories of phonetic attention and provide practical insights for improving spoken language communication in diverse real-world settings.

Babel, M., McAuliffe, M., Norton, C., Senior, B., & Vaughn, C. (in press). The Goldilocks Zone of Perceptual Learning. *Phonetica*.

Senior, B. & Babel, M. (2018). The role of unfamiliar accents in competing speech. *Journal of the Acoustical Society of America*, 143 (2), 931-942.

McAuliffe, M., & Babel, M. (2016). Stimulus-directed attention attenuates lexically-guided perceptual learning. *The Journal of the Acoustical Society of America*, *140*(3), 1727-1738.

Babel, M. & Russell, J. (2015). Expectations and Intelligibilty. *Journal of Acoustical Society of America*, *137*(5), 2823-2833

3. Biases and Stereotypes in Speech Perception and Spoken Language Processing

An ongoing debate in spoken language processing is how social information affects spoken language processing. For example, a hot topic is whether a loss of intelligibility can stem from a lack of listener effort. Babel and Russell (2015) showed that Asian Canadians' speech was less intelligible that the speech of White Canadians only when listeners knew they were listening to the speech of Asian Canadians. Using standard instruments to measure social and racial attitudes, we argued that these results appear to be the results of erroneous linguistic predictions and not a lack of listener effort. Associations between speaker populations and linguistic forms inhibited accurate identification of the stimuli. Similarly, Szakay, Babel, and King (2016) show

that for Maori-English bilinguals in New Zealand, listeners associations between languages facilitate cross-linguistic processing.

Senior, B., Hui, J. & Babel, M. (2018). Liu vs. Luke? Name influence on voice recall. *Applied Psycholinguistics,* 1-30. doi:10.1017/S0142716418000267.
Wong, P., & Babel, M. (2017). Perceptual identification of talker ethnicity in Vancouver English. *Journal of Sociolinguistics*, *21*(5), 603-628.
Szakay, A., Babel, M., & King, J. (2016). Social categories are shared across bilinguals' lexicons. *Journal of Phonetics*, 59, 92-109.
Babel, M. & McGuire, G. (2015). Perceptual fluency and judgments of vocal aesthetics and stereotypicality. *Cognitive Science*, 39, (4), 766-787.
Babel, M., McGuire, G., & King, J. (2014). Towards a More Nuanced View of Vocal Attractiveness. *PLOS ONE*, 9, 2, 1-10.

4. The interaction of speech perception and phonology.

Our language teaches us how to listen. My work in this area has demonstrated how experiences with language shape our perceptual space (Johnson & Babel, 2010). We have also shown, however, that listener sensitivity to psychoacoustic contrasts can be increased by “tricking” participants into exploiting less language specific processing strategies (Babel & Johnson, 2010). For challenging auditory contrasts that are low in perceptual salience, my colleagues and I have found that listeners exploit auditory general contrast effects to predict phoneme categories (Babel & McGuire, 2013). Additionally, we have shown that ambiguity in visual speech information feeds cross-linguistic patterns of sound change (McGuire & Babel, 2012). This line of research has improved our understanding of how cross-linguistic differences in sound structure affect communication break downs in adult populations.

Babel, M. & McGuire, G. (2013). Listener expectations and gender bias in nonsibilant fricative perception. *Phonetica, 70*, 117-151.
McGuire, G. & Babel, M. (2012) A cross-modal account for synchronic and diachronic patterns of /f/ and /θ/ in English. *Journal of Laboratory Phonology*, 3, 251-272.
Babel, M. & Johnson, K. (2010). Accessing psycho-acoustic perception with speech sounds. *Laboratory Phonology,* 1 (1), 179-205.
Johnson, K. & Babel, M. (2010). On the perceptual basis of distinctive features: Evidence from the perception of fricatives by Dutch and English speakers. *Journal of Phonetics*, 38 (1), 127-136.

A full set of publications can be found at https://scholar.google.ca/citations?user=NTm7MhAAAAAJ&hl=en

D. Research Support

Ongoing:

Social Sciences and Humanities Research Council Insight Development Grant, Babel (PI), 6/1/2018-5/31/2020

Documenting Urban and Regional Accents in BC

The languages we speak and the accents we speak with provide insight into our identities and histories. In this project we are creating an accent map of British Columbia (BC) to describe the regional varieties of English that comprise the linguistic landscape of the province. Using computational techniques in linguists’ and musicians’ toolkits, we have developed an online system to allow for the recording of urban and rural BC English speakers from their own homes. With a custom-written story as our elicitation material, we will create an accessible repository for researchers and communities. The proposed work will permit an understanding of how social and regional identities intersect with language, which is important in a globalized society.

Natural Sciences and Engineering Research Council Discovery Grant, Babel (PI), 4/1/2018-3/31/2023

Competition and evaluation in perceptual learning of speech
The focus of this research program is to test the weighting of signal-based and knowledge-based information in spoken language recognition by exploring the limits and constraints of perceptual learning in non-clinical adult listeners. With this population, we study lexically-guided perceptual learning: that is, how known linguistic information (in the form of known words) facilitates the recognition of a deviant or ambiguous acoustic-phonetic signal (e.g., hearing a known word with a controlled mispronunciation). This particular type of perceptual learning is critical as it is assumed to be exploited in daily communication when we interact with speakers or machines whose pronunciation deviates from the expected.

Social Sciences and Humanities Research Council Insight Grant, Babel (PI), 4/1/2017-3/31/2022

Socially Selective Phonetic Memory
This project examines the role of social group membership on how we perceive and process spoken language. For example, language users acquire the language varieties spoken around them; infants who grow up in a French-speaking environment learn to speak French, not German. We tend to mirror patterns of our linguistic input in our own linguistic output. In this SSHRC award we explore whether this is always the case. There is evidence in language acquisition that children start to craft their speech in gender-specific ways before the onset of puberty-induced anatomical differences. That is, children start to sound like little boys and little girls before it is an anatomically inevitability. What is the mechanism underlying the use of these selective language patterns? This award supports studies that explore the hypothesis that selective acquisition of speech patterns is driven by a socially selective attentional mechanism determined by group membership in the form of ingroup biases (e.g., preferences for those who are members of the same social group as oneself).

Completed:

Social Sciences and Humanities Research Council, Babel (PI) 4/1/11-03/31/2012

Phonetic Imitation: Units and Mechanisms
The results of the research funded by this SSHRC award examined phonetic imitation. Phonetic imitation is the unintentional and subconscious process of adopting the speech patterns of others. The research probed both the mechanisms and units behind phonetic imitation. The mechanisms of phonetic imitation were examined by testing two theories: one which predicts that cognitively novel or atypical voices would be subject to increased imitation, and another which predicts imitation is driven largely by social cognition such that one's social preferences would drive imitative behavior. To test these theories we first conducted a series of experiments asking independent groups of listeners to assess typicality and attractiveness of a corpus of voices. Based on these measures we selected voices which were most and least typical (less and more cognitively novel voices, respectively) and most and least attractive (more and less socially preferred, respectively) to our listener population for use in the phonetic imitation experiments. The results of our phonetic imitation tasks provided support for the theory that phonetic imitation is supported by cognitive novelty, as participants imitated the atypical voices the most. Female participants, however, imitated the attractive voices more than male participants, thus providing some support to the theory that phonetic imitation is facilitated by social preferences. In publications stemming from this SSHRC-funded research, we connect these findings to reported in differences in exemplar memory for females and males, along with females' purported stronger feeling of group membership. These results of this research are impacting theories in a diverse range of disciplines, including linguistics and the cognitive sciences, more broadly. More specifically, this SSHRC-funded research is shaping theories of speech perception and production, new dialect acquisition, and language change.

PHS 398 Cover Page Supplement

OMB Number: 0925-0001

Expiration Date: 03/31/2020

1. Vertebrate Animals Section

Are vertebrate animals euthanized? ❍ Yes ● No

If "Yes" to euthanasia

Is the method consistent with American Veterinary Medical Association (AVMA) guidelines?

❍ Yes ❍ No

If "No" to AVMA guidelines, describe method and provide scientific justification

2. *Program Income Section

*Is program income anticipated during the periods for which the grant support is requested?

❍ Yes ● No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

*Budget Period *Anticipated Amount ($) *Source(s)

Tracking Number: GRANT12729780 Funding Opportunity Number: PA-18-489 . Received Date: 2018-10-15T15:01:25.000-04:00

PHS 398 Cover Page Supplement

3. Human Embryonic Stem Cells Section

*Does the proposed project involve human embryonic stem cells? ○ Yes ● No

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://grants.nih.gov/stem_cells/registry/current.htm. Or, if a specific stem cell line cannot be referenced at this time, check the box indicating that one from the registry will be used:

❑ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

Cell Line(s) (Example: 0004):

4. Inventions and Patents Section (Renewal applications)

*Inventions and Patents: ○ Yes ● No

If the answer is "Yes" then please answer the following:

*Previously Reported: ○ Yes ○ No

5. Change of Investigator/Change of Institution Section

❑ Change of Project Director/Principal Investigator

Name of former Project Director/Principal Investigator

Prefix:

*First Name:

Middle Name:

*Last Name:

Suffix:

❑ Change of Grantee Institution

*Name of former institution:

PHS 398 Modular Budget

OMB Number: 0925-0001
Expiration Date: 03/31/2020

Budget Period: 1

Start Date: 06/01/2019 End Date: 05/31/2020

A. Direct Costs

	Funds Requested ($)
Direct Cost less Consortium Indirect (F&A)*	[redacted]
[redacted]	[redacted]

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	Funds Requested ($)
1.	[redacted]	[redacted]	[redacted]	[redacted]
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number): DHHS: Arif Karim, (214) 767-3600

Indirect (F&A) Rate Agreement Date: 05/11/2018

Total Indirect (F&A) Costs: [redacted]

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($): [redacted]

Funding Opportunity Number: PA-18-489. Received Date: 2018-10-15T15:01:25.000-04:00

PHS 398 Modular Budget

Budget Period: 2			
Start Date: 06/01/2020 End Date: 05/31/2021			
A. Direct Costs			Funds Requested ($)
	Direct Cost less Consortium Indirect (F&A)*		[redacted]
	[redacted]		
	[redacted]		[redacted]

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	Funds Requested ($)
1	[redacted]	[redacted]	[redacted]	[redacted]
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number): DHHS: Arif Karim, (214) 767-3600

Indirect (F&A) Rate Agreement Date: 05/11/2018

Total Indirect (F&A) Costs: [redacted]

C. Total Direct and Indirect (F&A) Costs (A + B) — Funds Requested ($): [redacted]

Funding Opportunity Number: PA-18-489. Received Date: 2018-10-15T15:01:25.000-04:00

PHS 398 Modular Budget

Cumulative Budget Information

1. Total Costs, Entire Project Period

Section A, Total Direct Cost less Consortium Indirect (F&A) for Entire Project Period ($) [redacted]

[redacted]

2. Budget Justifications

Personnel Justification [redacted]_Personnel_Justification.pdf

Consortium Justification

Additional Narrative Justification

Tracking Number: GRANT12729780
Funding Opportunity Number: PA-18-489. Received Date: 2018-10-15T15:01:25.000-04:00

Budget Justification

Senior/Key Personnel

Benjamin Munson, Ph.D. (Principal Investigator): PI Dr. Munson will devote 12.5% academic year effort (1.125 calendar months) in both years of the project. Munson will coordinate all phases of the project. Munson's position in the Department of Speech-Language-Hearing Sciences gives him protected research time to devote to this study, and the salary funds in this grant will provide him with an additional one-course teaching release. Dr. Munson will supervise the postdoctoral fellow for this project. He will also be responsible for writing and managing the IRB protocol for this project.

Peggy Nelson, Ph.D. (co-Investigator). Co-I Dr. Nelson will devote 5% academic year effort (0.45 calendar months) in both years of this project. Nelson will assist in the recruitment and audiometric testing of individuals with hearing impairment for specific aim 2 of this study. Nelson will also assist in the development of the final protocol for determining the presentation of the audio stimuli (i.e., determining a signal-to-noise ratio that is appropriate for the entire range of individuals in the study, and verifying the implementation of the HAL protocol for providing uniform amplification to individuals with hearing impairment). Nelson (and co-I Oxenham) will meet with PI Munson monthly during all phases of this project, and will coauthor selected presentations and publications from this study.

Andrew Oxenham, Ph.D. (co-Investigator). Co-I Dr. Oxenham will devote 5% academic year effort (0.45 calendar months) to this project. Oxenham will assist in the recruitment of older adults with and without hearing impairment for specific aim 2 of this study. He will assist in the preparation of the audio stimuli. Oxenham will be centrally involved in the analysis of the speech perception data from older adults for specific aim 2 of this study, and in particular in the comparison of intelligibility performance between the novel sentences developed in this study, and the standard-of-care sentences that will be recorded. Oxenham (and co-I Nelson) will meet with PI Munson monthly during all phases of this project, and will coauthor selected presentations and publications from this study.

Evelyn Davies-Venn, PhD (Consultant): Consultant Dr. Davies-Venn will devote 2% academic year effort (0.18 calendar months) in both years of this project. Davies-Venn has considerable expertise on health and wellness outcomes in individuals with hearing impairment, and on modeling perception by individuals with hearing impairment. She will provide assist Munson, Nelson, and Oxenham on recruitment of older adults with hearing impairment, and on the interpretation of the individual-differences measures of the older adults with and without hearing impairment. Davies-Venn will meet with PI Munson and co-Is Nelson and Oxenham in a full project team meeting quarterly.

Jeffery Simpson, Ph.D. (Consultant). Consultant Dr. Simpson will devote 1% academic year effort (0.09 calendar months) in both years of this project. Simpson has extensive expertise in social psychology. He will provide consultation on the selection and interpretation of the IAT measures for this study, and on the interpretation of information about listeners' social networks. Simpson will meet with PI Munson and co-Is Nelson and Oxenham in a full project team meeting quarterly.

Matthew Winn, Ph.D. (Consultant). Consultant Dr. Winn will devote 2% academic year effort (0.18 calendar months) in both years of this project. Winn has considerable expertise on the acquisition and analysis of eye-tracking data in individuals with hearing impairment and normal hearing. He will assist in the development of the eye-tracking components of the experiment protocol, and in analyzing the eye-tracking data. He will also provide guidance on the analysis of individual differences in the older adults with and without hearing impairment. Winn will meet with PI Munson and co-Is Nelson and Oxenham in a full project team meeting quarterly.

Other Personnel

TBA (Postdoctoral fellow): The TBA postdoctoral fellow (PF) will dedicate 100% of her/his time (12 person-months) in both years of this project. The PF will be responsible for the day-to-day implementation of this project, including creation of the stimuli, running subjects, and analyzing data. The PF and PI Munson will meet weekly during both years of this project, and will participate in all monthly and quarterly team meetings. The PF will supervise the work of the undergraduate RA on this project. The PF will be given the opportunity to take the lead in giving presentations and writing manuscripts summarizing selected topics from this project. The The PF position in this project can hold a PhD in a number of different academic fields, including audiology, speech and hearing science, psychology, and linguistics. The PF will also work with PI Munson, co-Is Nelson and Oxenham, and the collaborators to develop skills outside of her/his primary expertise (i.e., interpreting audiometric results if the PF does not have training in audiology, administering and scoring IATs if the PF does not have training in social psychology)

TBA (Undergraduate Research Assistant): The TBA undergraduate research assistant (URA) will dedicate 10 hours a week (10 months) in both years of this project. The URA will work under the direction of the PF. She/he will be responsible for assisting in stimulus preparation, subject testing, and data archiving. The URA will meet with the PF weekly, and will attend the quarterly full project team meeting.

Consultant

Molly Babel, Ph.D. (Consultant). Consultant Dr. Babel will dedicate 100 hours of effort in each year at $50/hr (in Year 2, an additional $5000 is also requested for consultant travel costs). Babel has extensive expertise on audiovisual speech perception and on social influences on phoneme perception and speech intelligibility. She will provide guidance and feedback on the video stimuli, and on developing the parts of the protocol that relate specifically to AV perception. Babel will also serve as a co-author on selected presentation and publications from this study, particularly those related to individual differences among the younger, normal-hearing adults.

OMB Number: 0925-0001
Expiration Date: 03/31/2020

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A. Specific Aims

Hearing impairment (HI) affects a large percentage of older adults: 8.5% of 55-64 year olds, 25% of 65-74 year olds, and 50% of people 75 and older have a HI that is sufficiently severe to be disabling [36,42]. HI is associated with negative social and health outcomes [35,53]. One of the most significant consequences of HI is a reduced ability to perceive speech and, consequently, a reduction in social interaction. This decrease in social interaction may be the cause of many of the broader impacts that HI has on health and well-being. Improving speech perception by individuals with HI is of great public health relevance. Because of demographic shifts in the US, interactions between older adults and the younger adults (including those in caregiving roles) are increasingly likely to be between individuals with different racial and ethnic backgrounds: older adults in the US are more likely than younger adults to be white and non-Latinx [44,54]. These population dynamics are likely to provide an additional challenge to speech perception by individuals with HI beyond those posed by the sensory deficit itself, as recent research has found evidence that **speech intelligibility can decrease when a listener becomes aware of a talker's race and ethnicity** by seeing a picture of a talker, especially when the talker is a person of color (i.e., Latinx, non-white, or both). That is, some intelligibility decrements are due to social factors alone, and are not due to the acoustic and linguistic characteristics of the speech being perceived, or the listener's auditory acuity [6,37,48]. Given demographic shifts, **effects of speaker race and ethnicity on speech intelligibility are likely to be of great significance to the population of older adults with HI**. Understanding *when* and *why* these **r**ace and ethnicity **e**ffects on **i**ntelligibility (REI) occur is a critical first step to mitigating or removing them.

However, there are **two barriers** to studying REI that must be removed before large-scale studies on this topic can be conducted. **The first barrier** concerns the fact that the speech stimuli that are used in clinical assessments and in research on individuals with HI are inadequate for studying REI. These are generally audio-only (A-only) materials. The visual component of audio-visual (AV) signals is a rich source of social information about talkers, including their race and ethnicity—features that are not conveyed robustly through A-only signals. The stimuli needed to study REI are by necessity AV, and existing corpora of AV speech stimuli [16] do not have the racial and ethnic diversity needed to study REI. **The second barrier** is that there are no data on REI in individuals with HI. It is possible that listeners with HI show *similar or larger REI* than individuals with normal hearing [NH], if they ignore or avoid critical visual speech cues—ones that are needed to compensate for the cues that their auditory impairment renders imperceptible—when presented AV speech by people of color. This hypothesis is suggested by work on face perception across race and ethnicity [14,58]. An alternative hypothesis stems from the finding that decrements in hearing ability prompt individuals with HI to attend to visual speech cues even more robustly than NH individuals [14,59]. If this increased visual attention occurs regardless of talkers' race and ethnicity, then individuals with HI should show *smaller REI* than NH individuals, because the NH individuals would ignore critical visual speech cues produced by racially and ethnically diverse talkers, while HI individuals would attend to these cues. More generally, the lack of large-scale experiments on REI means that we know relatively little about the perceptual and cognitive mechanisms that underlie REI across the lifespan and across levels of hearing acuity. This R21 grant will exploit our research team's expertise on corpus development and annotation, hearing impairment, auditory perception, social psychology, and sociolinguistics to move past the barriers identified above and set the stage for larger-scale work on this vitally important topic.

Specific Aim 1: **To build a large corpus of AV speech stimuli produced by racially and ethnically diverse individuals**. The speech materials will include standard-of-care sentences commonly used in clinical research (IEEE Sentences, [26]), as well as a new set of sentences designed to elicit socially meaningful phonetic variation. These will be produced by a set of men and women who are diverse in race and ethnicity. We will share this corpus in a digital archive, along with de-identified data on the intelligibility of these stimuli (collected for specific aim 2). These speech stimuli will be more appropriate to assess the abilities of the increasingly diverse population of individuals in the US with HI than a corpus of decontextualized speech produced by a small, homogenous set of talkers.

Specific Aim 2: **To determine the *extent* and *nature* of effects of talker race and ethnicity on the intelligibility of speech presented to NH and HI listeners**. This will be achieved by using the stimuli developed in specific aim 1 (both the standard-of-care sentences and the newly developed ones) in a series of AV and A-only intelligibility experiments with both behavioral responses and eye tracking. Younger NH, older NH, and older HI participants will serve as listeners. These data, along with a set of individual-differences measures, will be used to test different hypotheses about the locus of REI, and to determine whether REI is larger or smaller in HI listeners than in NH listeners.

B. Significance

B.1. Social influences on speech perception

Problems understanding speech are a hallmark of hearing impairment (HI), a communication impairment that affects numerous Americans, including a strikingly high percentage of older adults [36,42]. Understanding the nature of speech perception challenges by adults with HI is a pressing public health challenge, as untreated HI has far-reaching and potentially devastating effects on health and well-being [35,53]. The focus of this grant is on an aspect of speech perception that has traditionally been ignored in speech perception research and which is of great importance to society: the influence of talkers' race and ethnicity on their speech intelligibility to individuals with and without HI.

Speech communication is a quintessentially social act. The premise underlying this application is that standard-of-care measurements of speech perception, such as those for individuals with HI, are suboptimal because they ignore social factors. For example, assessment of speech perception by individuals with HI generally use single words or contrived sentences (*Bring your problems to the wise chief, Ducks fly north but lack a compass*) [26]. Moreover, the talkers and speech styles of these materials are generally not varied systematically. They tend to be produced in a careful speech style by a small number of talkers whose demographic characteristic are unspecified. The decontextualized nature of speech perception assessments is greatly at odds with the inherently social nature of speech communication, and with the growing body of literature showing that speech perception is sensitive to *social information* [18]. Social information is expansive [5]; in this application we use this term more narrowly to refer to attributes about the people whose speech is being perceived, such as their gender identity, their social class, and, most especially, their race and ethnicity. Social information and speech perception interact in a bidirectional manner. Listeners use patterns of phonetic variation to infer attributes about talkers like age, gender, race, ethnicity, social class, emotion, and attitudes toward topics being discussed [8]. In turn, listeners' assumptions about the social characteristics of talkers affects lower-level aspects of speech perception. For example, the labeling of an ambiguous phoneme can differ when different attributes about the talker who produced it are suggested to a listener. A fricative that is ambiguous between /s/ and /ʃ/ is more likely to be labeled as [s] when listeners believe it was produced by a man, and [ʃ] when thought to be produced by a woman [52]. This is true even when the speaker sex is cued very subtly, for example, by combining the ambiguous fricative with a vowel whose f0, voice quality, and formant frequencies are gender-neutral, and then pairing this doubly ambiguous stimulus with a picture or video of a man or a woman's face [39,41]. These effects are particularly interesting because they cannot be attributed to peripheral auditory processes: the very same acoustic signal is perceived differently when the talker's gender is suggested by a visual prime, albeit in ways that are consistent with actual population-level differences between men and women's voices. Similar visual-priming effects on phoneme perception have been found for a variety of vowel and consonant contrasts and a variety of social categories other than gender (i.e., age [19], race [20,25], geographic origin [43]). For example, [20] recently showed that listeners label children's productions of /ld/-final words with a completely or partially elided /d/ as more-accurate when paired with African-American child's face than when paired with a white child's face. This presumably reflects listeners' knowledge that some African American children speak African American Vernacular English (AAVE), a variety of English in which the normative production of a word like *cold* is [kʰoʊl] rather than [kʰoʊld]. Social factors can affect performance on a variety of tasks beyond perception. For example, [4] showed that listeners imitate less phonetic detail in speech when spoken stimuli are paired with African-American people's faces (suggesting that the speech was produced by them) than when paired with white people's faces; this tendency was strongest for individuals whose performance on an implicit association test (IAT) suggested implicit biases against African Americans.

Social effects on speech perception extend more broadly to language comprehension, as measured by sentence intelligibility tasks. [37] showed that Mandarin-accented English was more intelligible when presented with an ethnically Chinese person's face than when paired with a white person's face. The magnitude of the differences between these conditions and a third condition using a race-neutral silhouette was mitigated by listeners' experience interacting with Mandarin speakers. Again, these effects are not driven by aspects of the signal: the intelligibility of the same speech varied depending on which visual stimulus it was paired with. Research by [62] suggests that race effects might be grounded in audiovisual integration: audiovisual integration was less effective for ethnically Korean faces paired with Korean-accented English than for white faces paired with unaccented English. [27] found that speaker attitudes about talkers mitigated social effects on intelligibility: measures of implicit and explicit attitudes toward accented talkers uniquely predicted their speech intelligibility, beyond other signal- and listener-rated factors (i.e., the language variety used in the

stimuli, the listeners' executive function and age). Social effects on intelligibility extend beyond accented speech. In a seminal study, [48] presented connected speech (a university lecture) produced by a native Midwestern American speaker (i.e., someone without a foreign accent), paired with either a white person's face or an ethnically East Asian person's face. Undergraduate students remembered less information from the lecture, and judged the unaccented speaker to be more highly accented when the audio sample was paired with the East Asian person's face than when paired with a white person's face. [6] showed that the intelligibility of sentences produced by 12 native speakers of Canadian English (6 of whom were white, 6 of whom were ethnically Chinese) differed depending on whether the sentences were presented along with pictures of the speakers' faces. For the ethnically Chinese speakers, intelligibility was lower when these sentences were presented with their faces as compared to a condition where no face was presented. For white speakers, there was no intelligibility cost associated with revealing the speaker's face.

In the remainder of this application, we refer to the findings in the previous paragraph as **r**ace and ethnicity **e**ffects on **i**ntelligibility [REI]. We use both the terms *race* and *ethnicity* so not to conflate differences between the two major ethnic groups in the US (Latinx, non-Latinx) and the major racial categories in the US (African-American, East Asian, South Asian, Native American, white, etc.), as is consistent with NIH reporting requirements. The existence of REI has strong, pressing implications for our understanding of the challenges faced by individuals for whom speech perception is most difficult: people with hearing impairment (HI), as described in detail in section B.2, below. Prior to studying REI in individuals with HI, a number of key barriers in this area of study must be removed. We must better understand the specific mechanism(s) that drive(s) REI, and conduct rigorous and reproducible experiments that evaluate them directly. There are at least three hypotheses for why REI occur, none of which is mutually exclusive from the other two. One hypothesis is that images of speakers elicit expectations about the language variety that the speaker uses. For example, seeing an ethnically East Asian person's face might lead someone to expect to hear an accented variety of English, despite the fact that not all ethnically East Asian people speak with accents. Seeing an African American person's face might prompt people to expect to hear a non-mainstream variety of English like AAVE. This ***expectation-driven hypothesis*** is invoked specifically by [19,20,62], but has not been tested directly. Furthermore, this hypothesis is surprisingly very challenging to test rigorously. It predicts that qualitatively different perception errors should occur when perceiving speakers of different ethnicities. However, the nature and extent of those errors is likely to be mitigated by the amount of experience that listeners have interacting with people of different races and ethnicities. For people with less experience interacting with diverse populations, expectations are likely not to be a viable source of information. A second hypothesis is that REI occur because people have negative attitudes toward the individuals whose speech they are perceiving, and that these negative attitudes make processing more effortful, and consequently less accurate. This hypothesis is supported by the results of [27], and by other work using related paradigms, like [4]. This ***attitude-driven hypothesis*** calls for larger-scale studies of the relationship between attitudes toward different groups and the intelligibility of those people's speech in A-only and AV conditions. A third hypothesis relates to the nature of AV perception of different speakers: talkers whose race and ethnicity are different from that of the listener might elicit different patterns of visual speech perception from same-race, same-ethnicity talkers. It is well documented that individuals perceive the faces of people who do not share their race and ethnicity much more coarsely than those of people who share their race and ethnicity [14,58]. This may lead to differences in visual attention during AV speech perception: an individual who is listening to and viewing a racially or ethnically different speaker might not attend to phonetically relevant visual signals, especially mouth movement, as when viewing a person whose race and ethnicity are the same as theirs. This is explanation was invoked by [1,62], but has never been tested systematically by looking at eye gaze during perception. This explanation is unlikely to explain the results of studies using static visual images, but may explain why it could be hard to *learn* the phonetic characteristics of ethnically and racially diverse talkers. This ***attention-driven hypothesis*** suggests that studies of REI should include measures of visual search from eye-tracking during speech perception, to examine whether attention to phonetically relevant visual signals differs across races and ethnicities. These three mechanisms might interact. For example, the processing challenges associated with negative attitudes might reduce the efficiency of visual search, as was found by [1].

B.2. Sources of variation in speech perception by people with hearing impairment

One of the most commonly occurring communication disorders is hearing impairment (HI). When compared to normal hearing (NH) individuals of the same age, individuals with HI interact socially less, have less participation in the workforce, and are at a greater risk for other health problems like dementia [33,35,36,53,55]. Maximizing the communication of people with HI is of enormous relevance to public health,

as better communication can mitigate or alleviate the negative social, cognitive, and vocational consequences of HI. The REI described in section B.1 are of particular importance to individuals with HI. Changing demographics in the US mean that there are likely to be racial mismatches between older Americans and younger ones: each successive generation of Americans contains fewer non-Latinx white people, and more racial and ethnic diversity overall, than the one prior to it. Moreover, the workforce of individuals providing day-to-day caregiving and health care support for older adults (including home health care assistants, certified nurses' assistants, audiologists, speech-language pathologists, etc.) is younger than the people they care for, and hence is more likely to comprise people of color (i.e., people who are Latinx, non-white, or both) [44,54]. In short, older adults with HI are more likely than the general US population not to be people of color, and the individuals that they interact with in critical roles are more likely than the general US population to be people of color. These demographics sets the stage for many real-world interactions that mirror those in [6,27,37,48,62]. This motivates the current project, the ultimate goal of which to build a large set of carefully constructed speech stimuli to study REI in NH and HI adults, to use these stimuli in a series of experiments designed to measure the extent of REI in A-only and AV tasks by three groups (older adults with HI, older adults with NH, and a large, diverse cohort of younger adults with NH), and to use the results of these studies to determine the mechanism underlying REI more generally.

Very little is known about how social factors like those described in section B.1 affect speech perception by adults with HI. One exception is [59], who found that phoneme identification by listeners with CIs was more strongly affected than NH listeners by pictures that revealed talker gender, using a task like that in [39,41,52]. Examining REI in listeners with HI accomplishes a number of important goals. The first speaks to the external validity of standard-of-care speech perception assessments. If REI is larger in HI listeners than in NH listeners, then we can conclude that the assessment of speech intelligibility using a small set of talkers likely under-predicts the speech perception success of individuals with HI in real-world interactions across races and ethnicities. Studying REI in older adults also helps us better understand the mechanisms that drive REI. As a group, older adults in the US are likely to have less interaction with racially and ethnically diverse peers than younger adults, at least among their same-age peers. Consistent with this, research has shown them to have more negative views of individuals in other races and ethnicities, at least in the cases of white adults' evaluations of nonwhite individuals [24]. The increase in the range of implicit attitudes toward different races and ethnicities will allow us to make a more robust test of the attitude-driven hypothesis. The changes in visual attention during speech perception that occur with age and hearing impairment [15] allow us to make a more-robust test of the attention-driven hypothesis. In short, including older adults with HI in this project has both practical and theoretical motivations.

B.3. Barrier: The lack of a resource to study REI.

There is at least one substantial but surmountable barrier to conducting large-scale studies of REI: the lack of an audiovisual database of speech stimuli produced by individuals of diverse races and ethnicities. The first aim of this grant is to build such a database. In specific aim 2 of this project, this new database will be used in a series of studies that test the hypotheses outlined in section B.1 about the locus of REI, and those in B.2 about the magnitude and locus of REI *differences* between older adults with and without HI. While specific aim 2 is a solidly exploratory aim, it is important to emphasize that specific aim 1 will have a lasting and sustained impact on science regardless of the outcomes of specific aim 2. The database will be made available to the scientific community through a digital archive. This will allow researchers to use these stimuli in any future clinical or research studies. The ethnic and racial diversity in this corpus makes it a socially valid instrument for assessing speech perception in an increasingly more-diverse population of individuals with HI. This is particularly important in light of the lack of racial and ethnic diversity within the profession that measures speech perception in HI in the US, audiology, in which only 8% of professionals are non-white and 3% are Latinx [47].

C. Innovation

The innovation in this project is at least threefold. First, the end result of this project will be a new corpus of audiovisual speech stimuli that is radically different from all existing corpora (e.g., [16]). It will include both standard-of-care sentences, and sentences that are designed specifically to elicit more natural speech styles. These will be produced by a group of talkers that is ethnically and racially diverse. Second, the results of this project—and the results of the work that inspired it [6,37,48]—suggest that the fields of speech perception and audiology should reconsider the long-standing assumption that AV speech perception is always better than A-only speech perception (e.g., [10,17,21]). That hypothesis is based on studies of A-only and AV speech perception using stimuli produced by a homogeneous set of talkers. Research with more-diverse speaker populations may show that AV perception can be significantly poorer than A-only perception in cases of racial

and ethnic mismatch between talker and listener. Finally, this project will evaluate a potentially important source of variation in speech perception that has hitherto not been considered in studies of HI.

D. Approach

D.1. Speech Materials

The first specific aim is to develop a corpus of AV speech stimuli produced by a racially and ethnically diverse group of talkers. From each talker, we will record two types of sentences. One set will be a subset of the standard-of-care IEEE sentences [26]. These will be recorded because they are the standard sentences used in much speech intelligibility research. We will also develop a new set of sentence materials to be recorded. The overall goal in developing this new list is to craft sentences that speakers might use in real-world communication, and which consequently would be more likely to elicit a more natural, real-world speech style.

To make the materials socially meaningful, we will mine repositories of internet blogs and select all declarative sentences that have 5-7 content words, as is true of the IEEE sentences. We will then eliminate the sentences that contain words that are not in the English Lexicon Project (ELP, [7]). This will remove proper names (includes places and people), slang, taboo words, and very low-frequency words. We will then randomly select 1000 sentences that a researcher deems to be (a) syntactically well-formed, (b) appropriate for use in an experiment (i.e., they contain no offensive content), and (c) free from first-person statements that would imply that the sentence represents the talker's views. A second individual will then review these 1000 sentences. In all instances where there is not perfect agreement on the neutrality and research-appropriateness of the sentence, it will be discarded. We anticipate the final set will include 750 sentences.

The phonemic balance of the lists will not be controlled, but the phonemic composition of the lists will be measured and reported, as will the frequency and potential confusability (estimated from the phonological neighborhood density) of the words comprising the sentences, taken from the ELP. We will be able to use these measures to examine post-hoc whether they account for sentence-level intelligibility differences.

Each talker will produce 50 of the 750 sentences, including a set of 10 sentences that all speakers will produce, and 40 other sentences. Each talker will also produce 50 IEEE sentences, including 10 that all talkers will produce, and 40 other IEEE sentences. All of these sentences will be made available in the public archive, even if they are not ultimately used in specific aim 2.

D.2. Talkers

We will recruit and record a group of 50 18-40 year old talkers to produce the stimuli. Half of the talkers will be men and half will be women. We will recruit equal numbers of talkers from five different race/ethnicity categories: (1) non-Latinx white, (2) Latinx of any race [most of whom we anticipate to be white Latinx individuals], (3) African American/Black, (4) South Asian, and (5) East Asian. Our choice of these five categories is motivated by a combination of sensitivity to US and world demographics, and pragmatic reasons. The first three categories are the dominant race/ethnicity categories in the US, comprising approximately 84% of the population. While South Asian and East Asian individuals make up only 5% of the US population, they make up the nearly half of the world’s population. We anticipate none of our talkers will produce an accented variety of English. All of the talkers will have begun to acquire English in the US no later than age 7. This age is within the range that is broadly agreed to be the critical period for language acquisition, at which time languages can be acquired with little or no foreign accent. Talkers will be recruited from the University of Minnesota undergraduate and graduate-student populations, and will leverage the social networks of the diverse students that work in the PI and co-I's laboratories.

D.3. Recording

We will use a high-resolution, high frame-rate camera (GigE Prosilica 680 cameras with Kowa C Mount lenses) to video-record the talkers for specific aim 1. Sentences will be elicited in a reading task. The newly developed sentences will be read in the original contexts in which they occurred in blogs. We anticipate that the reading in context, particularly in the context of a blog, will elicit a more natural speech style than reading a single sentence in isolation. Talkers will be recorded from the neck upward using professional-grade video lighting, a consistent and neutral background, and at a consistent distance from the camera. Individuals' necks, faces, and hair will be visible in the recording. Individuals will be asked to pull their hair back from their faces so that the eyebrows can be seen. We will instruct individuals to dress and use makeup as they normally would, so that any semiotic markers of social-group membership and individual identity are present, as is true in real-life social communication. Headwear will be permitted only it is something the talkers habitually wear for cultural or religious reasons (e.g,. hijab, kippah, taqiyah, dastaar), as these items are generally worn habitually in public and are hence encountered in real-world social communication. Individuals who wear face-covering clothing (e.g., a niqab or burqa) will not be eligible to participate as talkers. During the video recording, a separate audio

recording will be made, using a professional-grade boom microphone and a digital recorder. Hence, the audio recordings for both the A-only and AV sentences will be very high quality.

D.4. Listeners

The listeners will be 120 individuals, divided into three groups, based on age and hearing status: younger (18-40]) with NH (NYH, n=60), older (60-90) with HI (OHI, n=30), and older with NH (ONH, n=30). Equal numbers of men and women will be recruited within each group. The older adults with HI will all use hearing aids (HAs). The absence of a younger HI group is due to the lower incidence of hearing loss in younger people. The criteria for normal hearing in the YNH group will be audiometric thresholds of no more than 20 dB HL at octave frequencies between 250 and 8000 Hz. For the ONH group, the criteria will be relaxed to allow for thresholds up to 60 dB at frequencies of 4 and 8 kHz. However, the degree of high-frequency hearing loss will be recorded and used as a covariate in analyses, if needed. For the OHI group, inclusion criteria include sensorineural hearing loss with no conductive component, with pure-tone average audiometric thresholds between 500 and 2000 Hz between 40 and 65 dB HL, and no pure-tone thresholds exceeding 75 dB HL at 4 and 8 kHz. All participants will be native speakers of English.

This project endeavors to recruit a racially and ethnically diverse population of listeners. This will be achieved by using University of Minnesota community engagement mechanisms, as well as partnerships that PI Munson built during a previous grant that examined low-income children (grant R01 DC02932). Given demographic changes, we anticipate that the YNH group will be more diverse than the ONH and ONI groups.

D.4. Listening Tasks

Prior to conducting any intelligibility tasks, we will run a series of baseline tasks in which we will play A-only stimuli to listeners and ask them to guess the race and ethnicity of the talkers. These data will be used to estimate the extent to which race and ethnicity can be garnered from voices alone. It is unclear what we will find. Some previous work has found that certain racial and ethnic categories can be estimated from A-only signals [45], but those studies used very different stimuli from those proposed in the current project. If we find that race and ethnicity can be estimated from A-only signals, we will use the proportion of accurate identification of race and ethnicity in the A-only condition as a covariate in all of our analyses of the effect of race on intelligibility.

In the main experiment, listeners will complete two listening tasks: an A-only intelligibility task, and an AV intelligibility task. In the A-only condition, listeners will hear sentences over headphones and will type their response in a GUI. Each listener will be presented with 10 different sentences each from a quasi-random subset of 20 of the 50 talkers (2 men and 2 women from each of the race/ethnicity categories). The 10 sentences will include 5 of the standard-of-care sentences, and five of the sentences from the new corpus developed for this study. No sentence will be repeated twice in the experiment. The decision to use only a subset of the talkers is based on largely practical grounds: our previous work has found that 200 sentences is the maximum that participants can tolerate in a listening task. In the AV task, listeners will view and listen to the same 20 talkers producing a different set of sentences. The same response GUI will be used. In this task, we will capture the subjects' eye movements using Tobii T60 XL eye-tracker during the entire interval during which the talker's face is present (i.e., the sentence, and 500 ms intervals prior to the sentence). The order of the A-only and AV tasks will be randomized across participants.

The masking noise will be a 4-talker babble, created via random concatenation and mixing of talkers and sentences not used in the experiment. The SNR will be based on pilot experiments and will be different for the three groups so that the percentage of keywords repeated is in a similar range for all subjects. In both tasks, the auditory stimuli will be presented diotically over headphones. For the NH groups, the level of the target will be set to 65 dB SPL. For the HI listeners, the stimuli will be spectrally shaped and amplified according to the NAL-NL2 formula [32] for each listener individually to ensure audibility. Gain will be adjusted if necessary based on subject complaint using the procedures described in [28].

D.5. Individual-Differences Measures

For YNH, ONH, and ONI listeners, we will collect or measure pure-tone audiograms. We will also collect aided audiograms for OHI listeners. For all three groups, we will administer a series of IATs [20,49], which measure individuals' preconscious attitudes toward the five racial and ethnic categories in this grant. The selection of the specific IAT measures will be guided by consultant Prof. Jeff Simpson. We will also estimate the racial and ethnic diversity in individuals' peer groups using methods from [13]: asking the names of up to 15 people who would help the participant with a significant chore requiring group participation. This will allow us to estimate the racial and ethnic diversity in each listener's social group, and to use these measures in further exploratory analyses of factors that mitigate REI. Finally, we will include brief measures of cognition from the NIH toolkit,

as was done by [27]. This will allow us to test whether individual listeners' differences in REI are mitigated by processing fluency.

D.6. Stimulus Annotation and Dissemination

Each of the AV sentences that develop in specific aim 1 will be segmented and made available in a public archive, similar in design to other speech-stimulus archives (i.e., the ALLSSTAR corpus, [12]). The metadata will include the speakers' age, sex, and self-reported race and ethnicity, the proportion correct ethnicity perception in the A-only condition, and the proportion of each of the content words in the sentences that were correctly reported, separated by listener group (YNH, ONH, OHI). Given the high audio quality of these data, they will be potentially useful to speech production researchers or speech processing research (i.e., for studies of automatic classification of speakers' race and ethnicity from acoustic signals alone, [2]).

D.7. Intelligibility measures. For the listening task, we will measure each stimulus's intelligibility as the proportion of keywords (i.e., content words) correct per sentence. Listeners will be asked to type what they heard, via a computer keyboard. Scores will be first automatically tallied, and then all errors will be manually checked for potential misspellings or homophones, which will be marked as correct.

D.8. Eye-Tracking Measures

Following [57], we will define five areas on each talker's face: the mouth, the left eye, the right eye, the left forehead, and the right forehead. For each trial, we will calculate the proportion of eye fixations on each of the five areas of the face, on the remaining non-face areas of the person, both during the 500 ms interval prior to the sentence onset, and during the sentence itself.

D.9. Statistical Analyses

The statistical analyses will involve a combination of frequentist [2,8,9,34] and Bayesian [56] multilevel logistic modeling. Mixed-effects models will be used, as the specific talkers and items will vary across the individual listeners. Given that the goal of specific aim 2 is exploratory in nature, there is not a large body of literature on which to base a power analysis that would be needed for frequentist statistics to be used exclusively. In all of our analyses, the dependent measure will be the whether each of the content words was correctly reported.

The first set of analyses compares the two sets of speech materials. To determine whether the standard-of-care sentences and the newly created sentences have different intelligibility levels, we will run logit mixed-effects models predicting the probability of keyword recognition in A-only conditions as a function of sentence type.

The next set of analyses examines the mechanisms that underlie REI. To replicate [6], we will examine whether a model with condition (A-only vs. AV) fits data better than a model with talker race/ethnicity, both alone and in interaction with race/ethnicity. To evaluate the attention-driven hypothesis, we will examine whether a model that includes the proportion of time spent looking at the mouth improves fit compared to a model with only talker race/ethnicity and condition. If the model fits are significantly different, we can conclude that attentional factors are at least partly responsible for REI. In this case, we will run a series of models that examines the relationship between visual attention and accuracy across different race and ethnicity categories. To evaluate the attitude-driven hypothesis, we will examine whether a model that includes listeners' IAT scores fits the data better than a model with talker race/ethnicity and condition only. If the fits are significantly different, then we can conclude that attitudes drive REI, at least partly. We will follow up on this finding by running a series of models that examines the relationship between IAT and race/ethnicity in different conditions. To examine whether expectations drive REI, we will compare a model that includes the proportion of the person's peer group that is people of color (using the measures described in D.5) to a model that includes talker race/ethnicity and condition only. If the fits are significantly different, then we can conclude that expectations drive REI, at least partly. Finally, we will build a set of progressively more complex models that use multiple predictor variables to examine whether attention, attitudes, and expectations predict intelligibility in combination with one another.

These analyses will be followed by a series of analyses that include a variable coding the mismatch in race/ethnicity between the listeners and talkers in place of a variable coding talker race. This will allow us to assess whether REI reflects mismatches between talkers and listeners, or if it relates specifically to the perception of the speech of people of color.

The final set of analyses examines whether the effects from the previous paragraph are statistically equivalent across the three listener groups (YNH, ONH, OHI). In each of these analyses, group will be added to the most-complex models above. In cases where the addition of listener group results in significantly better model fit, we will re-run models examining the interaction between race/ethnicity and condition separately in the different listener groups.

PHS Human Subjects and Clinical Trials Information

OMB Number: 0925-0001 and 0925-0002

Expiration Date: 03/31/2020

Are Human Subjects Involved	● Yes ○ No
Is the Project Exempt from Federal regulations?	○ Yes ● No
Exemption Number	❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8
Other Requested Information	

Human Subject Studies

Study#	Study Title	Clinical Trial?
1	Race, Ethnicity, and Speech Intellig bility in Hearing Impairment and Normal Hearing	No

Section 1 - Basic Information (Study 1)

OMB Number: 0925-0001 and 0925-0002

Expiration Date: 03/31/2020

1.1. Study Title *

Race, Ethnicity, and Speech Intelligibility in Hearing Impairment and Normal Hearing

1.2. Is this study exempt from Federal Regulations * ❍ Yes ● No

1.3. Exemption Number ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8

1.4. Clinical Trial Questionnaire *

1.4.a. Does the study involve human participants?	● Yes	❍ No
1.4.b. Are the participants prospectively assigned to an intervention?	❍ Yes	● No
1.4.c. Is the study designed to evaluate the effect of the intervention on the participants?	❍ Yes	● No
1.4.d. Is the effect that will be evaluated a health-related biomedical or behavioral outcome?	❍ Yes	● No

1.5. Provide the ClinicalTrials.gov Identifier (e.g. NCT87654321) for this trial, if applicable

Section 2 - Study Population Characteristics (Study 1)

2.1. Conditions or Focus of Study

- Specific Aim 1: Record, annotate, and disseminate a large set of ethnically and racially diverse talkers producing a set of standard audiometric sentences, and sentences specifically created to elicit socially meaningful phonetic variation.
- Specific Aim 2: Determine whether talker race and ethnicity affect the magnitude the AV benefit to speech intelligibility in individuals with and without hearing impairment.

2.2. Eligibility Criteria

Specific Aim 1: Individuals who are recruited as talkers will be between 18 and 30 years old. They will have no past or current speech, language, or hearing impairment, per self-report. Given our goal of recruiting an ethnically and racially diverse group of talkers, we anticipate that some of our potential participants will not be monolingual speakers of English. We will limit participation to individuals who began to acquire English in the US, who use English as the primary language in the home and in their daily lives, and who began to acquire English no later than age 7. This age is within the range that is broadly agreed to be the critical period for language acquisition, at which time languages can be acquired with little or no foreign accent. Hence, we anticipate that none of our talkers will produce speech with a foreign accent. Given that the focus of this corpus is on audio-visual speech perception, people who wear face-covering clothing (e.g., a niqab or burqa) will not be eligible to participate as talkers. Headwear will be permitted only it is something the talkers habitually wear for cultural or religious reasons (e.g,. hijab, kippah, taqiyah, dastaar), as these items are generally worn habitually in public and are hence encountered in real-world social communication.

Specific Aim 2: Individuals in the younger, normal-hearing (YNH) group will be between 18 and 40 years old. They will have no past or current speech, language, or hearing impairment, per self-report. We will limit participation to individuals who began to acquire English in the US, no later than age 7. The criteria for normal hearing in the young group will be audiometric thresholds of no more than 20 dB HL at octave frequencies between 250 and 8000 Hz. The older hearing impairmed (OHI) and normal hearing (ONH) groups will be between 60 and 90 years old. For the older NH group, the criteria for normal hearing will be to have thresholds no more than 20 dB HL at octave frequencies between between 250 and 2000 Hz, and to have thresholds no more than 40 dB HL at 4000 and 8000 Hz. This relaxed criterion is due to the high incidence of threshold shifts in older adults due to normal aging processes. The thresholds for 2000 Hz and 4000 Hz will be recorded for the ONH group, and will be used as a covariate in analyses of differences between ONH and YNH groups. For the HI groups, inclusion criteria include sensorineural hearing loss with no conductive component with pure-tone average audiometric thresholds between 500 and 2000 Hz between 40 and 65 dB HL, and no pure-tone thresholds exceeding 75 dB HL at 4 kHz or above. Individuals in all three groups will be fluent English speakers, defined as individuals who began to acquire English no later than age 7, in the US, who use English as the primary language in the home and in their daily lives.

2.3. Age Limits	Min Age: 18 Years	Max Age: 90 Years
2.4. Inclusion of Women, Minorities, and Children	AVGrant_R21_HumanSubjects_InclusionOfWomenMinoritiesChildren.pdf	
2.5. Recruitment and Retention Plan	AVGrant_R21_HumanSubjects_RecruitmentAndRetention.pdf	
2.6. Recruitment Status	Not yet recruiting	
2.7. Study Timeline	AVGrant_R21_HumanSubjects_StudyTimeline.pdf	
2.8. Enrollment of First Subject	07/01/2019	Anticipated

Inclusion of Women and Minorities

Specific Aim 1: We will recruit equal numbers of talkers who identify as one of five different race/ethnicity categories (N=50 [25F, 25M] overall, N=10 [5F, 5M] in each category), as determined by self-report: (1) non-Latinx white, (2) Latinx of any race [most of whom we anticipate to be white Latinx individuals], (3) African American/Black, (4) South Asian [defined as people who identify as having ancestral roots in Afghanistan, Pakistan, India, Bhutan, Nepal, Bangladesh, Sri Lanka, or Maldives], and (5) East Asian [defined as people who identify as having ancestral roots in Mongolia, P.R. China, Taiwan, Korea, or Japan]. Our choice of these five demographic categories is motivated by a combination of demographics and pragmatic considerations. The first three categories are the dominant race/ethnicity categories in the US, comprising approximately 84% of the population. While South and East Asian individuals make up only 5% of the US, they make up the nearly half of the world's population. The inclusion of South and East Asian individuals will make this database more reflective of racial and ethnic diversity across the world. It is also broadly consistent with the race/ethnicity distributions in databases of static images of faces created previously, such as those described in [46]. In addition to demographic factors, the decision to limit the talkers to these five categories is partly for feasibility. These categories are well-represented in the population from which we will recruit the talkers. Talkers will be recruited from the University of Minnesota undergraduate and graduate-student populations, and will leverage the social networks of the ethnically and racially diverse students that work in the PI and co-Is' laboratories. These mechanisms for talker recruitment have been successful in previous efforts to recruit diverse talkers. This is not an exhaustive list of race/ethnicity categories in the US. It does not include culturally significant, smaller ethnic groups in the US, such as Native Americans, Native Alaskans, and Pacific Islanders. Moreover, the groups themselves comprise considerable internal ethnic variation. Increasing the size and diversity of this database is an important future endeavor, beyond the period of funding.

Specific Aim 2: This project will recruit a racially and ethnically diverse population of younger and older listeners. Our enrollment goals for different racial and ethnic categories was determined by taking the most recent figures from the US Census Bureau, and doubling the percentage of white, non-Latinx individuals that we seek to enroll. This was motivated by our goal of generating findings that will be appropriate for the more-diverse future generations, given the ongoing demographic changes in the US. Recruiting a diverse set of listeners is important to the success of this project. This will be accomplished by using University of Minnesota community engagement mechanisms, as well as community partnerships that PI Munson built during a previous grant that examined low-income children (R01 DC02932). Given demographic changes, we anticipate that the YNH (n=60 [30F, 30M]) group will be more diverse than the ONH (n=30 [15F, 15M]) and ONI (n=30 [15F, 15M]) groups.

Inclusion of Children

No individuals below age 18 will be included in this study. This exclusion is justified because this research has no direct therapeutic benefit, and because the materials and the experimental procedures are not appropriate for children.

Human Subjects Recruitment and Retention Plan

Participants for Specific Aim 1 will be recruited using two methods. The first of these will be advertisements in different University of Minnesota venues (i.e., newspapers, listservs for organizations of students of color, flyers, etc.) and in the community, particularly in university-affiliated organizations that serve communities of color (i.e., the Urban Research and Outreach-Engagement Center [UROC]). Younger, normal-hearing participants for Specific Aim 2 will be recruited through these same mechanisms. Older, normal-hearing participants will be recruited through University of Minnesota retiree groups, and by distributing flyers at University of Minnesota events that cater to older adults, such as the Osher Lifelong Learning Institute (OLLI). Older adults with hearing loss will be recruited through a participant database curated by the Julia M. Davis Speech-Language-Hearing Center, which is housed in the PI's home department, and by contacting individuals who have participated previously in co-I Nelson and Oxenham's research, and who have given consent to be contacted for future studies. These mechanisms have been used successfully in previous studies with these populations at the University of Minnesota.

The one-time nature of this study obviates the need for an explicit retention plan. However, we will write a biannual newsletter that we will share with participants and partnering organizations (i.e, UROC, OLLI). The newsletter will document the progress on the grant, and will highlights research on the topic of this grant in our lab and in others' labs. We will also create a project website, on which we will post similar information. These two tactics were used previously in PI Munson and colleagues' work with children, with great success. The project website has the additional benefit that it serves as a hub for students who are interested in contributing to this project through volunteering or conducting student research (as described in section 10, Facilities and Other Resources).

Human Subjects Study Timeline

Month of funding in year 1 (1-12), and prior to the start of funding (-1)

Activity	-1	1	2	3	4	5	6	7	8	9	10	11	12
Meet with stakeholders at potential recruitment sites, secure their agreement to advertise the study													
Develop new sentences for specific aim 1													
Develop recording and annotation protocol													
Recruit talkers													
Record talkers													
Segment stimuli													
Finalize data-collection protocol for specific aim 2													
Pilot-test protocol for specific aim 2 to determine optimal signal-to-noise ratio													
Recruit participants for specific aim 2													

Month of funding in year 2 (12-24)

Activity	13	14	15	16	17	18	19	20	21	22	23	24
Test participants for specific aim 2												
Analyze data from specific aim 2												
Finalize design of the digital archive to be used to disseminate the corpus from specific aim 1												
Write manuscripts summarizing results of this project												
Release the digital archive of stimuli for specific aim 1												

Inclusion Enrollment Reports

IER ID#	Enrollment Location Type	Enrollment Location
Study 1, IER 1	Domestic	University of Minnesota, Twin Cities

Inclusion Enrollment Report 1

Using an Existing Dataset or Resource* : ❍ Yes ● No

Enrollment Location Type* : ● Domestic ❍ Foreign

Enrollment Country(ies): USA: UNITED STATES

Enrollment Location(s): University of Minnesota, Twin Cities

Comments:

Planned

Racial Categories	Ethnic Categories				Total
	Not Hispanic or Latino		Hispanic or Latino		
	Female	Male	Female	Male	
American Indian/ Alaska Native	0	0	0	0	0
Asian	13	12	0	0	25
Native Hawaiian or Other Pacific Islander	1	1	0	0	2
Black or African American	8	9	1	0	18
White	24	23	7	8	62
More than One Race	1	2	0	0	3
Total	47	47	8	8	110

Cumulative (Actual)

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	0	0	0	0	0	0	0	0	0	0
Asian	0	0	0	0	0	0	0	0	0	0
Native Hawaiian or Other Pacific Islander	0	0	0	0	0	0	0	0	0	0
Black or African American	0	0	0	0	0	0	0	0	0	0
White	0	0	0	0	0	0	0	0	0	0
More than One Race	0	0	0	0	0	0	0	0	0	0
Unknown or Not Reported	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0

Section 3 - Protection and Monitoring Plans (Study 1)

3.1. Protection of Human Subjects	AVGrant_R21_HumanSubjects_ProtectionOfHumanSubjects.pdf
3.2. Is this a multi-site study that will use the same protocol to conduct non-exempt human subjects research at more than one domestic site?	❍ Yes ● No ❍ N/A
If yes, describe the single IRB plan	
3.3. Data and Safety Monitoring Plan	AVGrant_R21_HumanSubjects_DataSafetyAndMonitoring.pdf
3.4. Will a Data and Safety Monitoring Board be appointed for this study?	❍ Yes ● No
3.5. Overall structure of the study team	

Protection of Human Subjects

1. Risks to Human Subjects
a. Human Subjects Involvement, Characteristics, and Design

For Specific Aim 1, the procedures involve video- and audio-recording individuals producing a standard set of sentences used in audiological research [26], and a newly created set of sentences designed to have socially meaningful content, and to elicit a more natural, socially meaningful speech style than is generally elicited in productions of standard sentences. The standard sentences will be elicited with a reading task. The new sentences will also be elicited with a reading task, but the target sentences will be embedded in a longer stretch of text. The content of that text (i.e., the word choice, the topic) will be designed to elicit a natural speaking style (i.e., by using more colloquialisms, and by including topics that are socially engaging). Both types of sentences will be segmented, and used as stimuli for specific aim 2. Upon the completion of this project, the audiovisual and audio-only sentences created in specific aim 1 will be made available to the research community through a digital archive.

For Specific Aim 2, participants will complete a sentence intelligibility task. In this task, individuals will be presented with audio-only and AV sentences (created in specific aim 1) in the presence of background noise. They will type what they hear in a GUI. During the AV task, participants' eye movements will be tracked using a Tobii T60 XL eye-tracker, so that we can measure whether talker race and ethnicity affect the areas of the face that participants gaze at both before and during the production of target sentences. In addition, participants will complete (1) a series of implicit association tests to measure preconscious attitudes about race and ethnicity, (2) a series of brief nonverbal cognitive measures, and (3) a brief survey to estimate the racial and ethnic diversity in participants' peer groups.

For Specific Aim 1, participants will be healthy young adults aged 18-40. For Specific Aim 2, the participants will be healthy younger adults (aged 18-30) without hearing impairment, and older adults (60-90) with or without sensorineural hearing loss.

All of the research will take place at a single site, University of Minnesota.

b. Study Procedures, Materials, and Potential Risks

Specific Aim 1:
The procedures for this specific aim are entirely specific to research (i.e., none of these procedures is part of standard care). No existing records will be accessed. For this specific aim, the primary risk is that someone (i.e., a participant in specific aim 2, or a participant in any future study using the archive developed in this specific aim) will recognize one of the talkers who is recorded in specific aim 1, and subsequently ask the person something about their participation in this study that is inappropriate or uncomfortable. There is no way to prevent this from happening. The same risk applies to individuals who consented to be in corpora of faces. To mitigate this risk, we will provide extensive information to potential participants about this potential problem prior to recording. We will point participants to existing corpora (both audio-only corpora, like those in TalkBank, and static-image corpora, like those in the Tarr Lab's Face Place) as examples of the type of data that they will provide.

Specific Aim 2:
The only previously collected records that will be used in this study are audiological assessment data for the older, hearing-impaired participants. These will be collected only after participants have provided authorization to access HIPAA-protected health information. The procedures for specific aim 2 are commonly used in research and in audiological assessment. They pose no potential risk to participants, beyond the mild boredom and frustration that accompany any task requiring sustained attention. To mitigate that risk, we will provide frequent breaks.

2. Adequacy of Protection Against Risks
a. Informed Consent and Assent

Informed consent will be secured from all participants prior to testing. All individuals who secure consent (PI Munson, TBA Postdoctoral Fellow, and TBA Undergraduate Research Assistant) will have completed CITI training in the protection of human subjects in research. Prior to being scheduled to participate in Specific Aim 1, participants will affirm that they understand that the research involves creating archival recordings of their faces and voices. The consent form will only be signed after the potential participants have successfully answered comprehension questions about the study. In addition, the consent form for Specific Aim 1 will have a separate section, developed in conjunction with the University of Minnesota IRB and the office of external relations, in which participants will initial that they understand the different potential consequences of consenting to have their audio and video data shared in a public archive.

Prior to being scheduled in Specific Aim 2, participants will affirm that they do not have a legally authorized representative, and that they are able to consent to participate themselves. All consent-securing staff will be trained on the use of the University of California, San Diego Brief Assessment of Capacity to Consent (UBACC). In any cases where a researcher suspects that the potential participant might not have the capacity to consent, the UBACC will be administered. Participants who fail this screening will be excluded from the study. The consent form will only be signed after the potential participants have successfully answered comprehension questions about the study.

b. Protections Against Risk

All research assistants who administer the protocol will have been trained by PI Munson on its proper administration. PI Munson will develop the protocol-training procedures in collaboration with co-Is Nelson and Oxenham (whose expertise is in auditory perception) and consultants Babel and Simpson (whose expertise is in social perception and implicit attitudes).

All data will be stored on the PI's project server, access to which is limited to researchers on this project, and which is accessed through two-factor authentication. Paper data (i.e., consent forms) will be stored in a locked cabinet in the PI's faculty office.

c. Vulnerable Subjects, if relevant to your study

No vulnerable populations will be included in this research.

3. Potential Benefits of the Proposed Research to Research Participants and Others

We do not anticipate any direct therapeutic benefit to participants. The risks to the participants are minimal.

4. Importance of the Knowledge to be Gained

The knowledge to be gained in this study is of vital importance to society. Communication between older and younger adults often crosses lines of race and ethnicity. Preliminary work suggests that race differences introduce a barrier to speech communication. This study will be the first to examine whether these barriers disproportionately influence older adults with hearing impairment. It will also examine the mechanisms that might explain why race and ethnicity affect speech intelligibility in both older and younger adults. A better understanding of the mechanisms of these effects is needed before we can develop methods to mitigate or remove them. Moreover, the corpus of speech produced by racially and ethnically diverse individuals will be of great use to basic science research, and to clinical investigations of speech intelligibility.

Data and Safety Monitoring Plan

This project does not require a data safety monitoring plan, as it does not meet NIH's definition of a clinical trial. Hence, there is no need to appoint a monitoring board.

The only risk associated with this study is a loss of confidentiality if there is a data breach. To protect against this, all data will be stored on the PI Munson's project server, access to which he alone controls. The PI reviews access to the server on a quarterly basis, and removes access to individuals who have left the project.

Section 4 - Protocol Synopsis (Study 1)

4.1. Brief Summary

4.2. Study Design

4.2.a. Narrative Study Description

4.2.b. Primary Purpose

4.2.c. Interventions

Type	Name	Description

4.2.d. Study Phase

Is this an NIH-defined Phase III Clinical Trial? ❍ Yes ❍ No

4.2.e. Intervention Model

4.2.f. Masking ❍ Yes ❍ No

❑ Participant ❑ Care Provider ❑ Investigator ❑ Outcomes Assessor

4.2.g. Allocation

4.3. Outcome Measures

Type	Name	Time Frame	Brief Description

4.4. Statistical Design and Power

4.5. Subject Participation Duration

4.6. Will the study use an FDA-regulated intervention? ❍ Yes ❍ No

4.6.a. If yes, describe the availability of Investigational Product (IP) and Investigational New Drug (IND)/ Investigational Device Exemption (IDE) status

4.7. Dissemination Plan

Delayed Onset Studies

Delayed Onset Study#	Study Title	Anticipated Clinical Trial?	Justification
The form does not have any delayed onset studies			

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